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THE HONORABLE WILLIAM H. ALSUP

UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF CALIFORNIA
SAN FRANCISCO DIVISION

SIERRA CLUB, et al., Plaintiffs, v. STEPHEN JOHNSON, et al., Defendants, and SUPERFUND SETTLEMENTS PROJECT, et al., Defendant-Intervenors.	Case No. 3:08-cv-01409-WHA DECLARATION OF JUDY RIEDE

I, JUDY RIEDE, declare and state as follows:

1. I am over the age of 21 and competent to testify to all matters contained herein.

2. I reside with my husband at 95 Star West Drive, Afton, Wyoming 83110. We have lived in Afton for the past 7 years following my retirement from my job as an automotive engineer with General Motors, Inc. in Detroit, Michigan. I am a member in good standing of the Sierra Club. I am also a member of the Greater Yellowstone Coalition, the Natural Resources Defense Council and the Caribou Clean Water Partnership. I rely on these organizations to ensure that the environment I care about is managed in full compliance with applicable environmental laws.

3. My husband and I own land in the Crow Creek Valley adjacent to the Caribou-Targhee National Forest. We spent approximately 10 years looking for this property, prior to our retirements, and bought it in 1997. We specifically looked for property that had a trout stream, was near public fishing waters, and was free from development so that we could enjoy clean air, solitude, and wildlife. Our dream has been to build a home on this property and to live there for the rest of our lives. There is a small summer cabin on our land, where we spend a lot of time between April and November. We spend occasional time there in winter where access is by cross-country skiing (or snowmobile). Friends and family look forward to spending time at the cabin with us for all of the opportunities for both relaxing and recreation.

4. I was thrilled to be able to purchase property adjacent to the Caribou-Targhee National Forest that had two trout streams flowing through it, plus a large spring-fed pond (Books Spring) with trout. Both Crow Creek and Deer Creek originate in the Caribou-Targhee National Forest and provide habitat and spawning grounds for native cutthroat trout. These waters are also inhabited by brown trout. I was also thrilled to be adjacent to the National Forest because of the vast tracts of roadless land, the diversity of wildlife at our doorstep, the quiet, solitude, beautiful mountain views, and a healthy, unpolluted environment. The Blackfoot River, Salt River, and assorted small streams are within a short drive away, where we also can fish via public access. Our property appeared to be a dream come true and a total change from working

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and living in a highly industrialized mid-west area. Like most people, we naively thought we would be protected from industry and development because of proximity to a National Forest.

5. After purchasing our ranch, we consulted experts from the Nature Conservancy, U.S. Fish and Wildlife Service, Idaho Fish and Game, and the U.S. Forest Service as to how we could best improve the stream on the property for fish habitat and wildlife. We were told that there are about 400 plant species on our land, and that by removing cows and eliminating overgrazing the land would heal itself. No one at that time ever mentioned the phosphate mining that was occurring or proposed on the National Forest.

6. I first became concerned about phosphate mining near our land approximately 9 years ago, when my husband and I learned about the deaths of horses and sheep caused by eating forage with a high selenium concentration on land that was reclaimed after mining. This prompted my husband to contact BLM, Forest Service, J.R. Simplot, and conservation group personnel about the issue.

7. I subsequently learned that selenium is a naturally occurring element in Southeast Idaho that is exposed to air and water during the phosphate mining process. This exposure converts it to a form that is bio-accumulated up the food chain, where it is highly toxic above relatively low threshold levels.

8. I have learned that phosphate mines in southeastern Idaho are threatening the environment in the Caribou-Targhee National Forest. The Smoky Canyon Mine, which is the working phosphate mine closest to our property, is one of the most highly polluted mines in Southeastern Idaho. In fact, the release of hazardous substances from the Smoky Canyon Mine and the proposed expansion of the Smoky Canyon Mine in the Caribou-Targhee National Forest about 1.5 miles from our property directly threatens our dream and the value of our property. If selenium continues to be released from the current Smoky Canyon Mine operation, and even more selenium is released from a mine expansion, we may never again see the environment healthy enough to support fish in our streams or significant wildlife in our area.

9. I have read the Draft Environmental Impact Statement, Final Environmental

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Impact Statement, and Record of Decision for the expansion of J.R. Simplot's Smoky Canyon Mine. I have also read the responses from independent experts and the Greater Yellowstone Coalition. I have also read newsletters sent out by the Forest Service regarding mine activities and clean-up actions. I have participated in fish selenium studies (2006) with Greater Yellowstone Coalition and have read the resulting reports. I have personally discussed Smoky Canyon Mine clean-up and expansion with National Forest and BLM personnel in both private and public meetings.

10. I am aware of serious ecological damage from phosphate mining in southeastern Idaho. There is a warning by the Idaho Department of Environmental Quality (DEQ) at Mill Creek for children to limit fish intake because of high selenium. Another DEQ warning was for adults to avoid eating elk liver in game taken near mine operations. In 2006, the fish in Mill Creek appeared to be extirpated. Electro-fishing the water for a fish/selenium study in which I participated yielded no fish.

11. Based on the sources indicated, I have become aware that:

A. Southeast Idaho phosphate mines, including the Smoky Canyon Mine, have released selenium at levels toxic to fish and wildlife, and the persistence of this contamination will likely have serious adverse impacts on trout populations throughout southeast Idaho (Upper Snake River Basin). (Ref.: Van Kirk, R.W. and S.L. Hill. 2007. Demographic model predicts trout population response to selenium based on individual-level toxicity. Ecological Modeling 206: 407-420 (attached as Exhibit A) and Final Environmental Impact Statement, Smoky Canyon Mine, Panels F&G, Caribou County, Idaho, October 2007, Appendix 3B (attached as Exhibit B)).

B. Selenium levels in fish in the Sage Creek/Crow Creek area are increasing (Final Environmental Impact Statement, Smoky Canyon Mine, Panels F&G, Appendix 3B, Fig. 5 & Table 4) and levels in Deer Creek are higher than expected, as the previous Forest Service Director, Jerry Reese, stated that it is an un-impacted area. (Ref.: Feb 23, 1990 letter from Supervisor Reese to State BLM Director Martha Hahn. There is an old

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de-activated mine (Georgetown) upstream of Deer Creek that I have personally visited.

C. A peer-reviewed mathematical model that relates demographic trout populations and selenium levels was developed by Dr. R.W. Van Kirk of Idaho State University and S.L. Hill. This model predicts that cutthroat trout will have serious survival issues in Sage Creek and Crow Creek downstream of our property if selenium pollution from Smoky Canyon Mine continues as is. With continued mine expansion and selenium contamination projected, the fish populations in the creeks flowing through our property are likely to diminish as well. (Ref.: Van Kirk, R.W. and S.L. Hill. 2007. Demographic model predicts trout population response to selenium based on individual-level toxicity. Ecological Modeling 206: 407-420.)

D. Approximately seventeen of the southeast Idaho phosphate mines, including the Smoky Canyon Mine, are Superfund sites. A comprehensive clean-up of the sites, including the Smoky Canyon Mine, has not yet occurred. Therefore releases of hazardous substances from the mines, including those from the Smoky Canyon Mine, continue to pollute the environment of the Caribou-Targhee National Forest. (Ref.: Greater Yellowstone Coalition *et al.*, Final Environmental Impact Study Comments, Smoky Canyon Mine, Panels F&G. <u>See</u> Section III. C. (attached as Exhibit C)).

E. The J.R. Simplot Company is currently subject to a CERCLA Administrative Order on Consent for selenium contamination at their Smoky Canyon Mine. (Ref.: Draft Environmental Impact Statement, P. 3-21 and 5-14.) The mine operation has polluted wells, groundwater, streams, and springs with selenium levels above federal drinking water standards and water quality standards. Clean-up under the CERCLA order has started at only one of several sites (Pole Canyon). The first attempt at a fix was an almost immediate failure and effectiveness of the re-do in actually reducing selenium has not yet been demonstrated and documented. (Ref.: Final Environmental Impact Statement, Smoky Canyon Mine, Panels F&G, Caribou County, Idaho, October 2007, Appendix 2A. (attached as Exhibit D)).

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F. Clean-up of the mines' waste rock dumps that release selenium to the environment can be difficult and costly, with clean-up costs potentially reaching $173 million dollars at the Smoky Canyon Mine. (Ref.: Engineering Evaluation/Cost Analysis Smoky Canyon Mine, Caribou County, Idaho May 2006 (attached as Exhibit E)).

G. Bonds at the phosphate mines, including for the Smoky Canyon Mine, do not include funding for clean-up of hazardous substances. The difference between potential liability for clean-up and bonds for reclamation can represent tens of millions of dollars. In fact, the cost for clean-up of the Smoky Canyon Mine was estimated to be as high as $173 million, but the current reclamation bond for the mine is only $8.6 million. (Ref.: Final Environmental Impact Statement, Smoky Canyon Mine, Panels F&G, Caribou County, Idaho, October 2007, 2-14. Engineering Evaluation/Cost Analysis Smoky Canyon Mine, Caribou County, Idaho May 2006.)

12. Because of my concern over the pollution currently occurring at the Smoky Canyon Mine and the potential for even greater damage from mine expansion proposals, I have become increasingly active in efforts to prevent further selenium contamination from phosphate mining and to encourage the clean-up of existing contamination at the Smoky Canyon Mine.

13. My husband and I wrote a joint letter responding to the September 2003 scoping notice regarding the proposed expansion of the Smoky Canyon Mine. We each wrote a separate response to the request for comments on the Draft Environmental Impact Statement (DEIS) released in December 2005 and the Final EIS released in October 2007. My comments included my concerns about selenium contamination in southeast Idaho and selenium contamination of the water supplying our property.

14. Pollution of the Caribou-Targhee National Forest and Sage Creek Roadless Area from phosphate mining is starting to have a significant negative effect on my enjoyment of those areas. As indicated earlier, fish are gone from some creeks where they once thrived, and the high levels of selenium in some fish in Sage and Deer Creek prohibit sharing a meal of them with any children. Eating liver from game animals may be risky, and the true effects of selenium from

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Smoky Canyon Mine on birds, elk, deer, and moose have not been sufficiently studied in my opinion. I fear that selenium pollution originating from the National Forest will also have a significant negative effect on both the enjoyment of my own property and its economic value.

15. My husband is an ardent fly fisherman and spends as much time as possible fishing in Crow Creek and Deer Creek where they flow through our land. He also fishes Crow Creek downstream on National Forest land or with friends further downstream on Crow and Sage Creeks. I, too, occasionally fish or walk along for the enjoyment of the stream where he fishes. I also enjoy the wildlife, plants, and scenery.

16. The Forest Service and BLM's recent approval in June 2008 of the Smoky Canyon Mine Panels F&G Expansion as proposed in the FEIS and set forth in the Record of Decision threatens to contaminate all the main sources of water to our land with selenium. In Section 4.3-4 of the Final Environmental Impact Statement, the Agencies admit that their model predicts that mining Panel G of the Smoky Canyon Mine will cause selenium concentrations to exceed surface water standards in Deer Creek where it flows through our property. This will negatively impact fish and wildlife.

17. Selenium pollution would harm our interest in using and enjoying our property, as it would interfere with our ability to use these water sources for drinking water, horse grazing, and for maintaining and improving the wildlife and fish populations that these water sources sustain on our land. The mine expansion will destroy trails, streams, and springs where we frequently hike in the National Forest. The quiet, clean air, bird songs, and wildlife will be replaced by dust, diesel fumes, blasting, the roar of heavy equipment, and monster haul trucks.

18. My enjoyment of the land and the forest depend upon those areas of the forest remaining free from further pollution and contamination from phosphate mining. If the Superfund sites are not cleaned up and if the pollution from the Smoky Canyon Mine continues unabated, particularly when the mining operations are expanded to Panels F&G, my enjoyment of those areas will be seriously and irreparably harmed.

19. I am concerned that the J.R. Simplot Company will not have sufficient resources

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or will not be willing to devote sufficient resources to clean up their Smoky Canyon Mine in a complete and timely way that eliminates selenium pollution to groundwater and streams downstream from our property, which we use and enjoy.

20. I am concerned even more that if the J.R. Simplot Company is allowed to expand mining operations on public lands as approved in the Forest Service and BLM RODs, they will not devote sufficient resources to prevent contamination of more ground and surface water and they will not have sufficient resources or the willingness to use available resources to clean up their current and future mess. Both public lands and private lands will be contaminated by selenium. Because this expansion will likely contaminate the ground and surface water on our property, my husband and I ,as well as the general public, will bear the brunt of the cost for a private company's profit.

21. I am also concerned that other mining companies, in addition to the J.R. Simplot Company, will not have sufficient resources or will not be willing to devote sufficient resources to perform timely and complete clean-ups at the many other Superfund phosphate mine sites in southeast Idaho. With the expiration of the Superfund tax, there are insufficient federal funds for clean-up of such orphan sites in a timely manner. Thus I am concerned that the approximately 17 phosphate mines that are Superfund sites may not be cleaned up if the responsible parties cannot or will not fund the clean-ups. Southeast Idaho is already plagued by numerous "orphan" phosphate mines that continue to release selenium to the environment, but that are no longer operating and for which no viable corporate entity is responsible for clean-up.

22. Failure to clean up the phosphate mines in southeast Idaho in a timely manner will cause degraded water quality from selenium contamination, harm to fish and wildlife, and other environmental damage. This degradation will directly harm my interest in maintaining clean water, important habitat for Yellowstone cutthroat trout, and the scenery and amenities important to the economy of southeast Idaho and my community in southwest Wyoming.

23. If the U.S. Environmental Protection Agency had required mining and other companies that generate hazardous substances to provide sufficient financial assurance to

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actually cover the cost to clean up the pollution caused by their activities, the groundwater, streams, soil, and vegetation in the Caribou-Targhee National Forest would likely be significantly less contaminated. Without such financial assurances, I doubt that the pollution generated by phosphate mining will ever be cleaned up by the owners and operators of the mines.

24. If the U.S. Environmental Protection Agency requires operating phosphate mines in southeast Idaho to maintain financial assurance for clean-up of pollution from their operations, the mine owners will have greater incentive to operate the mine in a manner that prevents pollution in the first place.

25. If the U.S. Environmental Protection Agency requires the J.R. Simplot Company to maintain financial assurance adequate to clean up the pollution it has already caused as well as financial assurance to cover potential contamination from the expansion approved by the Forest Service and BL M, the mine is likely to operate with greater care for the environment. I would be more assured that if adequate bonding were in place to clean up contamination, there would be greater protection from the threats to my water, health, property values and aesthetic, and recreational interests.

26. I have a vested interest as a landowner who will be adversely impacted by phosphate mining in seeking timely and complete clean-up at the Smoky Canyon Mine and preventing additional selenium contamination, but my concerns are well beyond the bounds of my property. As a citizen who values clean air and water, I am horrified that Smoky Canyon Mine and the other phosphates mines are not required to post bonds or other financial assurance sufficient to cover the costs of clean up, given the admitted consequences to natural resources and the health and economic well being of my community. I am also horrified that the Agencies are approving expanded mining with the likely consequence of additional contamination without any assurance that current and past damage will be corrected.

27. Under the current scenario, there is no incentive for mining companies to prevent or clean up messes. The projected life of the Smoky Canyon Mine expansion is 16 years, but it

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may be 20-50 (or more) years before selenium concentrations peak. The adverse impact on the land and water is projected to last for centuries. Current bonding only covers reclamation where the mountains are re-graded and some minimal vegetation is planted. By the time selenium contamination peaks, the mining company will be long gone from the area.

28. Spokesmen for the southeast Idaho phosphate mining industry have publicly said that they cannot mine without polluting, and history has certainly proven this to be true. The contamination and pollution of National Forest lands from mining will decrease and cease only if the U.S. EPA stands up to protect the public by requiring financial assurance from mining companies, thereby ensuring that funds are available to address the pollution the mines create.

29. If the U.S. Environmental Protection Agency promulgates regulations that require companies that generate and handle hazardous substances to maintain financial assurances for clean-up, pollution of many other rivers and lands may be prevented and more timely and complete clean-ups may occur.

Pursuant to 28 U.S.C. § 1746, I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge. Executed this 29th day of August, 2008, at Afton, Wyoming.

Judy Riede

JUDY RIEDE

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EXHIBIT A

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Demographic model predicts trout population response to selenium based on individual-level toxicity

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ABSTRACT

A fundamental problem in ecotoxicology is prediction of population-level effects of toxicant exposure based on the response of individuals. We propose that stochastic population simulation can effectively address this problem and present an application to chronic selenium exposure in cutthroat trout. Decreased pre-winter survival and growth of juveniles due to selenium exposure were modeled by functions fit to toxicity test data. Density dependence in cutthroat trout populations occurs primarily in winter survival of juveniles, and this survival was modeled with a compensatory function calibrated to observational data. The model predicted that populations declined for a period of 10–40 years after exposure began but re-stabilized at lower equilibrium population sizes. These equlibria decreased sigmoidally with increasing selenium concentration. Toxicity-related juvenile mortality was the primary cause of population size decrease, and individual-level response was greater than population-level response until individual-level mortality exceeded 80%. Populations compensated for increased pre-winter mortality via decreased density-dependent winter mortality at selenium concentrations below 7.0–10.0 μg/g (whole-body, dry weight), depending on life history. At higher concentrations, equilibrium population size declined in the stochastic environment not because average juvenile survival rates declined but because variance in survival rates declined, preventing high survival during years in which fry production was low relative to carrying capacity. Our results suggest that: (1) when survival of individuals is density-dependent, population-level response to toxicant exposure may be lower than predicted based on individual-level response, (2) cutthroat trout populations will be protected at selenium concentrations not exceeding 7.0 μg/g, and (3) environmental stochasticity can significantly affect the response of population size to individual-level toxicity.

1. Introduction

A fundamental problem in ecotoxicology is how to predict population-level effects of pollutant exposure based on adverse toxic responses observed in individuals (Forbes et al., 2001; Stark, 2005). In order to protect fish and wildlife populations without unnecessary and potentially costly over-protection, regulatory mechanisms must be based on the effects of chronic pollutant exposure at the population level (Ferson et al., 1996; Forbes and Calow, 1999). The United States Environmental Protection Agency (USEPA) issues criteria for the protection of aquatic organisms that serve as guidance

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for States and Tribes authorized to establish enforceable water quality standards for pollutants under the Clean Water Act. To date, these and other such guidelines have generally been based on the results of acute and chronic toxicity tests in which mortality or reproductive effects have been measured for relatively small numbers of individual organisms exposed to water containing varying concentrations of pollutant (Walthall and Stark, 1997; Jager et al., 2004). To address the individual-to-population extrapolation problem, toxicologists have turned to population modeling, often in combination with field or laboratory toxicity tests (e.g., Kooijman and Metz, 1984; Stark and Vargas, 2005). However, the vast majority of population modeling studies of which we are aware have been applied to invertebrate organisms, which have relatively simple life cycles (e.g., Kuhn et al., 2000; Péry et al., 2006; but see Spromberg and Birge, 2005; Spromberg and Meador, 2005, 2006 for models applied to fish). More importantly, few of these studies have accounted for environmental stochasticity, which strongly affects population viability (Goodman, 1987; Dennis et al., 1991). We propose that demographically explicit stochastic population modeling can effectively predict population-level response in natural environments based on individual-level effects, and we illustrate this by modeling the effects of selenium exposure on cutthroat trout (*Oncorhynchus clarkii*) populations.

Selenium contamination has occurred world-wide in association with common and economically important activities such as fossil fuel processing, mining, and irrigation, resulting in dozens of cases in which fish and wildlife populations have been adversely affected (Skorupa, 1998; Lemly, 2004). Selenium contamination of surface waters has been documented in the Blackfoot and Salt river drainages of the southeast Idaho phosphate mining region (Hamilton and Buhl, 2003, 2004; Hamilton et al., 2004; Presser et al., 2004), one of the most extensive and productive phosphate fields in the world (Jasinski et al., 2004). Both of these river systems are tributary to the upper Snake River and currently support large populations of the Yellowstone cutthroat trout subspecies, *O. c. bouvierii* (Meyer et al., 2006). The Yellowstone cutthroat trout is a particularly appropriate study organism for the problem at hand because its demography and life histories are well known and because its native range includes the southeast Idaho phosphate mining region. Furthermore, because cutthroat trout are native to much of western North America, including many areas where potential for selenium contamination is high due to mining and irrigation (Seiler, 1998; Kennedy et al., 2000; Lemly, 2004), an assessment of the effects of selenium contamination on cutthroat trout populations is of broad interest. Although the U.S. Fish and Wildlife Service in 2006 declined a petition to list Yellowstone cutthroat trout for protection under the U.S. Endangered Species Act, it did identify selenium contamination in the Blackfoot and Salt watersheds as a threat to populations there (USFWS, 2006).

The bioaccumulative nature of selenium in aquatic systems is well known (Presser et al., 1994; Bowie et al., 1996; Dobbs et al., 1996; Maier et al., 1998; Garcia-Hernandez et al., 2000; Hamilton, 2002). Bioconcentration factors of 100–10,000 are possible in aquatic food organisms consumed by fish (Lemly, 1999). Furthermore, fish can have high tissue concentrations at hatch if selenium has accumulated in the female parent (Gillespie and Baumann, 1986). As a result, the concentration of selenium in water is not a good predictor of potential toxicity to fish, and there have been numerous proposals to replace the USEPA's 1987 selenium criterion of 5 μg/L in fresh water with criteria based on other media (e.g., Canton and VanDerveer, 1997; Lemly, 1999; Hamilton, 2002). Currently, selenium concentration in whole-body tissue is considered to be the most appropriate quantitative end point for assessment of selenium toxicity in fish (DeForest et al., 1999; Hamilton, 2002). In 2004, the USEPA proposed replacing its water-borne total selenium criterion for protection of freshwater organisms with a whole-body fish tissue concentration criterion of 7.91 μg/g (dry weight, USEPA, 2004).

Observed individual-level effects of selenium toxicity in fish include decreases in egg incubation period, hatch rate, pre-swim-up fry survival, post-swim-up juvenile survival, juvenile winter survival, juvenile growth, adult survival, and adult growth (Table 1). The majority of research on selenium toxicity in salmonid fishes has focused on juvenile survival and growth as end points, but we are not aware of any extrapolation of these individual-level effects to populations. Modeling shows that salmonid populations are sensitive to changes in juvenile survival (e.g., Hilderbrand, 2003; Spromberg and Meador, 2005, 2006), and thus it is possible that decreased juvenile survival due to selenium toxicity could result in decreased population size. However, because juvenile survival in trout is highly density-dependent, particularly during winter when individuals compete for limited concealment cover (Gregory, 2000; Mitro and Zale, 2002), trout populations may be able to compensate for increased juvenile mortality via reduced density-dependent effects. In other taxa, such compensation has been predicted by population modeling (Ferson et al., 1996; Grant, 1998) and observed in population-scale experiments (reviewed in Forbes et al., 2001).

Our approach is to structure, parameterize and calibrate a predictive model based on available field and laboratory data quantifying cutthroat trout demography and individual-level response to selenium exposure. Our objectives are to

(1) elucidate mechanisms linking individual- and population-level effects, with particular emphasis on environmental stochasticity and density dependence,
(2) propose selenium concentrations in fish tissue that are protective of cutthroat trout at the population level, and
(3) provide recommendations for assessment, regulation and management of contaminant effects on fish populations in natural settings.

2. Model description and analysis

In this section, we present relevant data supporting development of the model (Section 2.1), outline model structure (Section 2.2), provide details on density-dependence (Section 2.3), model calibration (Section 2.4), and response to selenium exposure (Section 2.5); and describe simulation and data analysis procedures (Section 2.6).

Table 1 – Reported individual-level responses of freshwater fish to selenium toxicity

Parameter	Warm-water fish		Salmonid fish	
	Effect	Reference(s)	Effect	Reference(s)
Fecundity	None	Gillespie and Baumann (1986), Ogle and Knight (1989), Hermanutz et al. (1992), Coyle et al. (1993)	None	Hardy (2005)
Time to hatch		Not studied	Decrease	Hodson et al. (1980)
Hatch rate	Decrease	Hermanutz et al. (1992)	Decrease	Hodson et al. (1980)
Pre-swim-up fry survival	Decrease	Gillespie and Baumann (1986), Woock et al. (1987), Hermanutz et al. (1992), Coyle et al. (1993)	None	Kennedy et al. (2000), Holm et al. (2005)
Post swim-up juvenile survival	Decrease	Woock et al. (1987), Coyle et al. (1993)	Decrease	Gissell Nielsen and Gissel-Nielsen (1978), Goettl and Davies (1978), Hilton et al. (1980), Hicks et al. (1984), Hunn et al. (1987), Hamilton and Wiedmeyer (1990), Hamilton et al. (1990)
Juvenile winter survival	Decrease	Lemly (1993b)		Not studied
Juvenile growth	Decrease	Woock et al. (1987), Lemly (1993b)	Decrease	Hilton et al. (1980), Hilton and Hodson (1983), Hicks et al. (1984), Hamilton et al. (1986), Hunn et al. (1987), Hamilton and Wiedmeyer (1990), Hamilton et al. (1990)
Adult survival	Decrease	Coughlan and Velte (1989), Hermanutz et al. (1992)	None	Hardy (2005)
Adult growth	Decrease	Coughlan and Velte (1989), Hermanutz et al. (1992)	None	Hardy (2005)

For parameters for which some studies reported no effect and others reported a statistically significant effect, only the studies reporting the significant effect are listed. If all studies reported no effect, then all are listed as such.

2.1. *Data supporting model development*

Cutthroat trout in the upper Snake River basin spawn in the spring and early summer (Kiefling, 1978; Thurow et al., 1988). Egg-to-fry survival is determined primarily by environmental conditions rather than by density (Magee et al., 1996; Koenig, 2006). Fry emerge from late May to late July, after which juveniles experience a growth period of about 90–150 days before the onset of winter. In absence of selenium effects, mortality is low during the summer growth period, and the vast majority of juvenile mortality occurs during the winter, as fish compete for limited concealment habitat. These observations are supported by data from Mitro and Zale (2002) and Mitro et al. (2003), who showed that survival of rainbow trout (*O. mykiss*) fry in the Henry's Fork Snake River is essentially 100% from swim-up to the onset of winter and is subsequently determined almost exclusively by available winter habitat, which, in turn, is determined by environmental conditions. Koenig (2006) reported similar results for cutthroat trout from tributaries to the Teton River, another upper Snake River basin stream. Once individuals have survived their first winter, they recruit to the population as age-1 subadults and subsequently survive at annual rates that are independent of age and density (Kiefling, 1978; Thurow et al., 1988; Varley and Gresswell, 1988). Fecundity is a function of spawner length, and sex ratios in upper Snake River basin cutthroat trout populations do not differ significantly from 1:1 (Meyer et al., 2003a).

Yellowstone cutthroat trout exhibit a resident life history, in which individuals spend their entire lives in relatively small headwater streams, and a migratory life history, in which individuals migrate between spawning and rearing habitat in headwater streams and more favorable foraging habitats in larger rivers or reservoirs downstream (Meyer et al., 2003a). Individuals displaying the migratory life history tend to grow faster, survive at higher rates, and mature later than resident fish (Kiefling, 1978; Thurow et al., 1988; Meyer et al., 2003a). All of these demographic attributes could contribute to differential susceptibility to selenium contamination between the two life histories (Spromberg and Meador, 2006).

We assumed that based on differences in physiology, individual-level responses of cutthroat trout to selenium toxicity might differ from those of warm-water fish species. Thus, despite the larger set of effects observed in warm-water species, we limited the effects included in our model to those widely reported in the literature for salmonid fishes, specifically, decreases in juvenile survival and growth (Table 1). All peer-reviewed research we could find that reported these effects in salmonids studied either rainbow trout or Chinook salmon (*O. tshawytscha*), which have similar early life-stage characteristics to those of cutthroat trout. We assumed that the effects of selenium on mortality and growth in juvenile cutthroat trout are similar to effects observed in these closely related species.

Among the early life-stage toxicological end points reported in these studies, those most relevant to the cutthroat trout life cycle are (1) survival of fry between swim-up and the onset of winter and (2) size of juveniles at the end of their first summer of growth. Because size-based fecundity in cutthroat trout is more strongly explained by length than by weight (Meyer et al., 2003a), we used length as the size end point. For concordance with the 90–150-day length of the juvenile growth period, we used mortality and growth data reported for exposure trials using newly emergent fry and lasting between 90 and 150 days. Furthermore, we used only those values for mortality and length measured at the end of the trial, as laboratory studies have shown that the effects of selenium exposure on juvenile trout increase substantially with time for the first 30–60 days of exposure, before leveling off as exposure duration increases (Goettl and Davies, 1978; Hunn et al., 1987; Hamilton and Wiedmeyer, 1990; Hamilton et al., 1990).

Despite Lemly's (1993b) observation of increased winter mortality in juvenile bluegills (*Lepomis macrochirus*) exposed to selenium, and the large body of literature documenting the importance of juvenile winter survival in salmonid life cycles (e.g., see review by Gregory, 2000), winter mortality in juvenile salmonids exposed to selenium has not been studied. Hence, we did not have taxon-specific data on which to base toxicity-related mortality estimates for any point in the cutthroat trout life cycle beyond the first summer of growth. Similarly, although reductions in growth rates of adults have been reported for warm-water fish (Coughlan and Velte, 1989; Hermanutz et al., 1992), no such response has been reported for salmonids, and thus our model does not include any reductions in growth due to selenium toxicity beyond that experienced by juveniles between swim-up and the onset of winter.

2.2. *Model structure*

The basic structure of the model is most easily illustrated in a life-cycle diagram (Fig. 1). Based on the literature reviewed above, we structured the population model by life stage and age class, assumed a 1:1 sex ratio (and hence tracked only females), and simulated both resident and migratory life histories. Abundances were calculated for eggs, emergent fry (referred to as simply "fry"), pre-winter juveniles, age-1 subadults, and adults in each of age classes 2 through maximum age (Fig. 1; Table 2). Transition between successive stage and age classes occurred via multiplication of abundance by the appropriate survival rate. As justified above, density-dependence was incorporated only in juvenile winter survival, and effect of selenium exposure on survival was incorporated only in summer survival of juveniles, which was assumed to be 1 in absence of selenium toxicity. All other survival rates were constant with respect to both abundance and selenium concentration. However, to incorporate environmental stochasticity, each of these rates was selected randomly in each year of the simulations from a normal distribution (truncated at 0 and 1) with a given mean and coefficient of variation (CV). These means and CVs were calculated from data reported in published studies of Yellowstone cutthroat trout populations in the upper Snake River basin (Table 2). The model did not incorporate demographic stochasticity; that is, all individuals within a stage or age class were identical.

To account for length-dependence in fecundity, we tracked length of individuals in a cohort. In absence of selenium toxicity, the length of all fish entering the age-1 class in a given year was selected randomly from a normal distribution (truncated at 0) with a given mean and CV (Table 2). Effects of selenium exposure were then incorporated by reducing this length by a given concentration-dependent percentage, as described in Section 2.5. Subsequent annual growth of individuals in a given cohort was modeled by adding the appropriate age-dependent increment, where the increment in a given year was selected randomly from a normal distribution with a given mean and CV (Table 2). The number of spawners of a given age was determined by multiplying the number of individuals in that age class by the appropriate age-dependent maturity rate (Table 2), and fecundity was calculated as a function of spawner length using the power–law relationship developed by Meyer et al. (2003a; Table 2). The number of eggs per spawner was then divided by two to obtain the number of females.

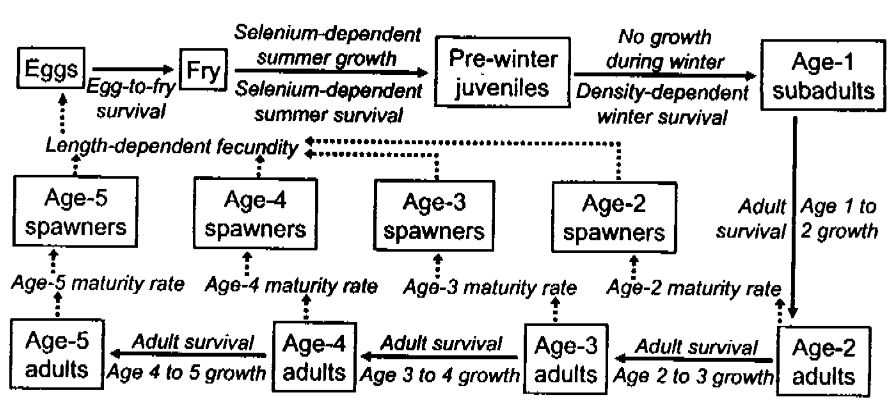

Fig. 1 – Life-cycle diagram for the resident life history form of Yellowstone cutthroat trout. Boxes indicate life stages for which abundance was calculated. Fish lengths were calculated for all subadult and adult life stages. Solid arrows indicate stage transitions via survival; dashed arrows indicate contributions via reproduction. The migratory life history differs only in that the maximum age is 6 instead of 5.

Table 2 – Model parameters and variables, by life history

Parameter	Resident	Migratory	Reference(s)
Egg-to-fry survival rate	0.225 (0.222)	0.225 (0.222)	Koenig (2006)
Selenium-dependent summer survival rate	1 − M, where M is mortality due to selenium exposure (Fig. 3)		See Fig. 3
Density-dependent winter survival rate	Eq. (1) and Fig. 2		See Section 2.3
Adult survival rate	0.353 (0.237)	0.420 (0.250)	Kiefling (1978), Thurow et al. (1988)
Maximum life span (years)	5	6	Kiefling (1978), Thurow et al. (1988), Meyer et al. (2003a)
Length (mm) at age-1	95.3 (0.100)	111.0 (0.191)	Kiefling (1978), Thurow et al. (1988), Varley and Gresswell (1988)
Growth increment (mm): 1–2	70.8 (0.270)	89.25 (0.237)	
Growth increment (mm): 2–3	68.8 (0.236)	91.0 (0.105)	
Growth increment (mm): 3–4	58.8 (0.194)	73.0 (0.110)	
Growth increment (mm): 4–5	62.0 (0.046)	66.5 (0.462)	
Growth increment (mm): 5–6		41.3 (0.334)	
Selenium-dependent summer growth	(1 − R) × (length at age-1), where R is fractional length reduction due to selenium exposure (Fig. 3)		See Fig. 3
Age-2 maturity rate	0.04	0	Meyer et al. (2003a)
Age-3 maturity rate	0.43	0.06	
Age-4 maturity rate	0.76	0.39	
Age-5 maturity rate	1	0.80	
Age-6 maturity rate		1	
Fecundity (eggs/spawner)	$F = 0.0026TL^{2.2255}$		

The mean and coefficient of variation (in parentheses) are given for environmentally determined parameters that vary randomly from year to year. In fecundity equation, F: fecundity and TL: total length (mm).

2.3. *Density dependence and model scaling*

The literature suggests that winter survival of juveniles follows a simple, compensatory model in which the number surviving approaches carrying capacity asymptotically as pre-winter juvenile abundance increases. Because we did not have data sufficient to allow estimation of the asymptotic approach rate directly, we developed a one-parameter family of survival curves. We then estimated the parameter by calibrating the entire population model to published values of juvenile survival rates in cutthroat trout, as described in Section 2.4. One such family of curves is defined by:

$$1 - \frac{y}{K} = \exp\left[-\left(\frac{x-y}{Ka}\right)\right]. \quad (1)$$

where x is the pre-winter juvenile abundance, y the age-1 abundance ($y \le x, y \le K$), K the winter carrying capacity for juvenile fish, and a the dimensionless parameter ($a > 0$).

Although Eq. (1) cannot be solved explicitly for y in terms of x, it defines a one-to-one relationship between the number of juvenile fish present at the beginning of winter (i.e., pre-winter juvenile abundance) and the number present at the end of winter (i.e., the number of fish that survive to recruit into the population as age-1 subadults). The resulting winter survival rate is y/x. The carrying capacity parameter, K, can be eliminated from Eq. (1) by defining the dimensionless variables $X = x/K$, which is pre-winter juvenile abundance expressed as a multiple of juvenile winter carrying capacity (x is generally larger than K), and $Y = y/K$, which is the number of individuals surviving the winter expressed as a fraction of this carrying capacity (y is always less than or equal to K).

Eq. (1) models a continuum of density dependence in juvenile winter survival (Fig. 2). It can be shown that in the limit as a approaches 0, Eq. (1) defines the piecewise-linear function labeled "$a = 0$" in Fig. 2 and models the case in which all individuals survive if pre-winter abundance is less than or equal to carrying capacity, K, and exactly K fry survive if pre-winter abundance exceeds carrying capacity. However, this situation would never be achieved in nature, as some individuals die regardless of how much winter habitat is available. As a increases, fewer of these individuals survive. For example, if pre-winter juvenile abundance is twice carrying capacity, the number of juveniles surviving the winter is equal to carrying capacity if $a = 0$, 72% of carrying capacity if $a = 1$, and 34% of carrying capacity if $a = 4$ (Fig. 2).

Because winter carrying capacity is strongly determined by environmental factors, and in particular by stream flow (Gregory, 2000; Mitro and Zale, 2002; Mitro et al., 2003), K is not constant, but rather varies stochastically around a fixed mean. In absence of data suitable for estimating a CV directly for this parameter, we assumed that environmental variability for juvenile winter survival rate is similar to that for the other stochastic parameters in the model and thus used a CV of 0.22, which is the mean of all of the CVs reported in Table 2. Justifications for this value are that it is a typical figure for variability in winter stream flow in the upper Snake River basin and that it is nearly identical to the CVs on environmentally determined parameters used by Hilderbrand (2003) in his data-driven stochastic model of cutthroat trout populations. In the dimensionless version of Eq. (1), the scaled carrying capacity is one, so in the stochastic model, the scaled juvenile carrying capacity was randomly selected each year from a normal distribution (truncated at 0) with mean 1 and CV = 0.22.

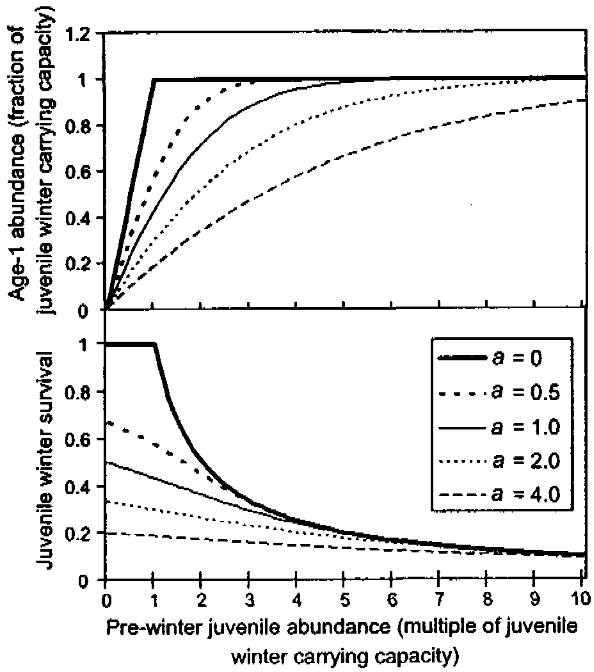

Fig. 2 – Abundance of age-1 fish (top) and resulting juvenile winter survival (bottom) as a function of pre-winter juvenile abundance, as defined by Eq. (1). The *a* = 0 function represents the limiting case in which mortality is determined strictly by habitat availability (density-dependent mortality only). The non-density-dependent component of mortality increases with *a*.

For general applicability, the desired model output is population size relative to population carrying capacity. Observed cases of selenium contamination in natural settings (e.g., Lemly, 2002) show that fish populations decline due to selenium toxicity at much lower environmental contamination levels than do organisms providing the prey base, and thus we assumed that this carrying capacity did not change with selenium contamination. To scale population size relative to carrying capacity, we first defined the total population size as the sum of abundances in age classes 1 through maximum age. Next, given that the dimensionless version of Eq. (1) expresses abundance of age-1 individuals per unit of juvenile winter carrying capacity, abundances in all subsequent age classes are expressed per unit of juvenile winter carrying capacity. We thus defined population carrying capacity, expressed per unit of juvenile carrying capacity, as the population size that would be obtained in deterministic equilibrium, which occurs when abundance of age-1 individuals is one and abundance in each subsequent age class n is given by s^{n-1}, where s is the mean adult survival rate. For example, the population carrying capacity for the resident life history is $\sum_{n=1}^{5} 0.353^{n-1} \approx 1.537$ individuals per unit of juvenile winter carrying capacity. In the simulations, the total population size computed in a given year of a given stochastic replicate was divided by this carrying capacity to express the population as a fraction of the deterministic carrying capacity, the desired dimensionless measure of population size.

2.4. *Model calibration*

The model was calibrated by identifying a range of realistic values for a based on published values of juvenile survival in cutthroat trout in absence of selenium toxicity. We defined this range as that above which juvenile survival was too low to maintain the population at carrying capacity and below which juvenile survival rates (fry to age-1) exceeded those reported in the literature. Populations were simulated without the effects of selenium toxicity at values of a ranging from 0 to 8.00 in steps of size 0.08. Calibration simulations consisted of 100 independent stochastic replicates initialized at carrying capacity. In each replicate, the population was simulated for 10 years (about two life spans) to eliminate effects of the initial condition, after which the replicate was continued for a randomly selected number of years between 1 and 100. The population size and other demographic variables were recorded for the given replicate in this selected year, resulting in a random sample of 100 independent values for each variable. Above $a = 1.20$, mean population size in resident populations was significantly lower (at $\alpha = 0.05$) than carrying capacity, and below $a = 0.40$, juvenile survival exceeded 50% in some years. Magee et al. (1996) observed cutthroat trout juvenile survival of nearly 50% in a sediment-laden stream in which egg-to-fry survival was extremely low, and this value is among the highest reported for cutthroat trout. Between $a = 0.40$ and 1.20, median juvenile survival rates fell within the 5–15% typically reported for cutthroat trout (Magee et al., 1996; Peterson et al., 2004; Koenig, 2006). Thus, we conducted most of the simulations incorporating toxicity at $a = 0.80$, but we also used $a = 0.40$ and 1.20 to test the sensitivity of model results to the parameter a.

2.5. *Effects of selenium concentration on mortality and growth*

Data allowing statistical analysis of juvenile mortality and growth as functions of selenium concentration were reported for appropriate trial durations in six peer-reviewed studies, lasting, respectively, 90 days (Hunn et al., 1987; Hamilton and Wiedmeyer, 1990; Hamilton et al., 1990), 112 days (Hilton and Hodson, 1983; Hicks et al., 1984), and 140 days (Hilton et al., 1980). To maintain consistency with USEPA's proposed criterion and reviews of selenium toxicity in fish (e.g., DeForest et al., 1999; Hamilton, 2002), we report all selenium values as concentrations in whole-body fish on a dry-weight basis. Where wet weights were reported in the original studies, we converted them to dry-weight concentrations assuming 75% moisture content, the figure most commonly used in analysis of selenium toxicity (e.g., Lemly, 1993a; DeForest et al., 1999; Hamilton, 2002, 2003). Two of the studies (Hilton et al., 1980; Hicks et al., 1984) reported concentrations only in liver tissue, and we converted these to concentrations in the carcass (i.e., whole-body without internal organs) with the function

$$\text{Carcass concentration} = 0.0513 \times \text{liver concentration} - 0.0172. \tag{2}$$

which was obtained by linear regression ($r^2 = 0.617$, $P = 0.0208$, $n = 8$) of data from two studies (Hodson et al., 1980; Hilton and Hodson, 1983) that reported both liver and carcass concentrations. Although carcass concentrations are slightly lower than whole-body concentrations, the error introduced by using carcass instead of whole-body concentrations is small compared to the statistical uncertainty that would result from omission of these data.

To determine the relationship between juvenile mortality and selenium concentration, we defined mortality due to selenium exposure to be $M = 1 - (s_t/s_c)$, where s_t is survival of treatment fish in a reported toxicity trial and s_c is survival of the control fish in the same trial. We used non-linear least-squares regression to fit the logistic function

$$M = \frac{1}{1 + \beta_1 \exp(-\beta_2 C)} \quad (3)$$

to the relationship between mortality, M, and tissue concentration, C (Fig. 3).

To determine the relationship between juvenile growth and selenium concentration, we used fractional reduction in length of treatment fish relative to that of control fish as the dependent variable, and determined the functional relationship with linear regression of this length-reduction variable against tissue concentration (Fig. 3). Although in theory this functional relationship is described by a logistic equation of the form (3), the available data do not include any length reductions equal to or exceeding 50%, and thus determination of a meaningful logistic function was not possible. However, the linear relationship is strong and is appropriate for application over the range of tissue concentrations relevant to this study. When response function values were below 0 or above 1 (Fig. 3), we assigned values of 0 and 1, respectively.

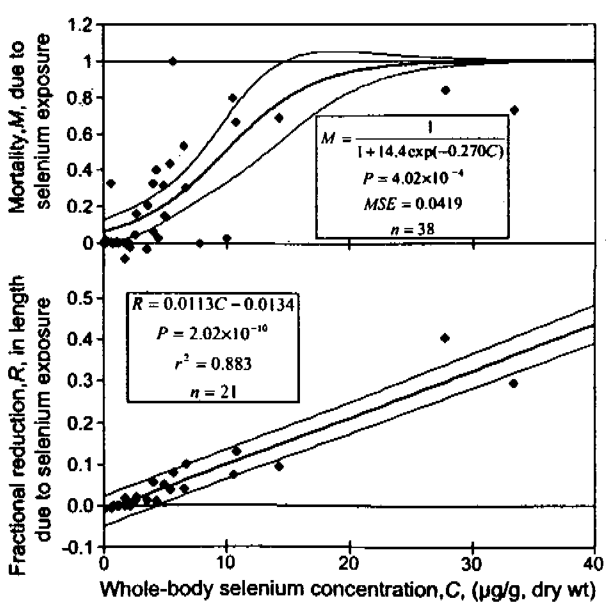

Fig. 3 – Mortality (top) and length reduction (bottom) due to selenium exposure in juvenile salmonids (data from Hilton et al., 1980; Hilton and Hodson, 1983; Hicks et al., 1984; Hunn et al., 1987; Hamilton and Wiedmeyer, 1990; Hamilton et al., 1990). Thick curves are least-squares fits to the data (expected values of toxicity response); thin curves define 95% CIs for the least-squares functions.

2.6. *Simulation and data analysis procedures*

Simulations investigated population size as functions of both time and selenium concentration. The time-series simulations consisted of 100 independent replicates of 80 years each, in which a population initially at carrying capacity was first exposed to a fixed selenium concentration in year 1. This procedure generated a random sample of $n = 100$ independent values of population size for each of the 80 years. For each year, we reported the sample mean and 95% confidence interval (CI) for the mean. The selenium concentration simulations were conducted at whole-body concentrations ranging from 0 to 40 μg/g in steps of 0.5 μg/g. For each concentration, we performed 100 independent stochastic replicates. In each of these replicates a population initially at carrying capacity was simulated for 10 years, after which simulation was continued for a randomly selected number of years between 1 and 100. The population size and other demographic variables were recorded for the given replicate in this selected year. This procedure generated a random sample of $n = 100$ independent values of each demographic variable at each selenium concentration, which could then be analyzed with standard statistical tests based on sampling distributions. Because biomass may be more ecologically relevant than population size in some settings, we tested the response of biomass to selenium concentration in one set of simulations. We calculated fish weight from the length data with a standard cubic power–law dependence of weight on length (Haddon, 2001) and then multiplied weight of fish in a given age class by abundance to obtain biomass.

To account for uncertainty in the individual-level effects, we performed simulations using upper 95% confidence limits, least-squares expected values, and lower 95% confidence limits for the predicted mortality and growth reduction response functions (Fig. 3). For each of the three sets of simulations, we recorded the concentration above which all 95% CIs for mean population size fell below carrying capacity (i.e., a dimensionless population size of one). Our point estimate of maximum no-effect concentration was that resulting from the simulations using the least-square expected values for the mortality and growth functions. Given the small concentration step size (0.5 μg/g) used in the simulations, the lowest observable-effect concentration is at most 0.5 μg/g greater than the maximum no-effect concentration. We therefore considered the maximum no-effect concentration to be the maximum concentration allowable to protect populations from decline. The concentrations from the simulations employing the upper and lower 95% confidence limits for mortality and growth reduction define a range for the point estimate. We analogously defined maximum 50%-effect and 90%-effect concentrations and their ranges.

We conducted all statistical hypothesis tests at the $\alpha = 0.05$ significance level.

3. Results

Resident populations exposed to sufficiently high selenium concentrations stabilized at subcarrying capacity equilibria

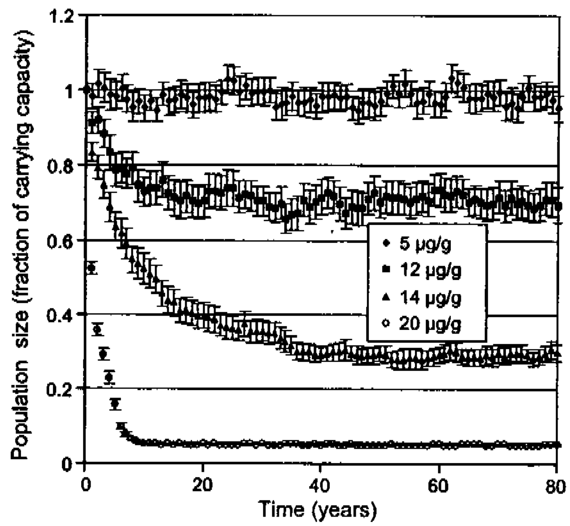

Fig. 4 – Population size vs. time from initial exposure for different whole-body selenium concentration values for the resident life history, a = 0.80, and expected values of toxicity response functions (Fig. 3). Each datum is the mean of annual population values from 100 independent stochastic simulations. Error bars show the 95% CI for the mean.

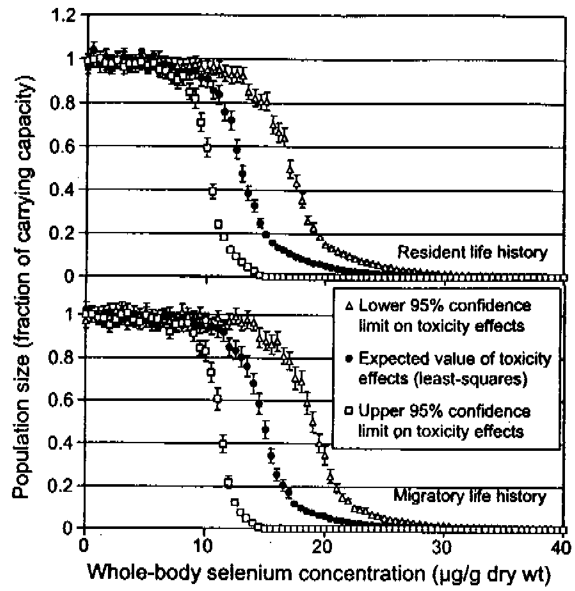

Fig. 5 – Population size vs. whole-body selenium concentration at a = 0.80. Each datum is the mean of 100 values, one randomly selected from each of 100 independent stochastic simulations. Error bars show the 95% CI for the mean.

after a period of decline ranging from about 10 to 40 years, depending on concentration (Fig. 4). Migratory populations showed similar patterns. Long-term population size for both life histories exhibited a decreasing, sigmoidal dependence on selenium concentration (Fig. 5). Plots of biomass relative to carrying capacity versus selenium concentration were not significantly different from those of population size, although biomass exhibited greater variability than population size. Resident populations were more sensitive to selenium exposure than migratory populations, but both life history types experienced 90% declines at mean concentrations exceeding about 17 μg/g (Table 3). Population-level response showed relatively little sensitivity to the density-dependent survival parameter a within the biologically realistic range (Fig. 6). As a increased from 0.40 to 1.2, the estimated 50%-effect concentration ranged from 12.0 to 14.5 μg/g for the resident life history and from 14.0 to 16.0 μg/g for the migratory life history.

The important demographic parameters affected by toxicity-related juvenile growth reduction and survival in our model are fecundity and fry-to-age 1 survival rate. Even though toxicity-related reduction in growth occurred only during the juvenile stage, size reductions experienced during this stage persisted to spawning age, and these reductions resulted in significant declines in fecundity (Fig. 7). Increases in selenium concentration up to about 13 μg/g for resident populations and 15 μg/g for migratory populations resulted in slight increases in median fry-to-age 1 survival, although these increases were not significant (Fig. 8). More importantly, the range of survival rates and in particular, the frequency of survival rates exceeding 25%, declined substantially with increasing selenium concentration. Above 15 μg/g, both the median and the range of observed survival rates declined severely.

4. Discussion

4.1. *Linking individual- and population-level responses*

Because it integrates survival, growth and reproduction across all individuals, population growth rate, r (or the finite rate of population increase, $\lambda = e^r$), is the end point most commonly used to quantify population-level response to toxicant exposure (e.g., Kooijman and Metz, 1984; Calow et al., 1997; Walthall and Stark, 1997; Kuhn et al., 2000; Roex et al., 2000; Snell and Serra, 2000; Jager et al., 2004). However, the response of popu-

Table 3 – Maximum no-effect, 50%-effect, and 90%-effect whole-body selenium concentrations (dry weight)

Population size reduction from carrying capacity	Resident life history (μg/g)	Migratory life history (μg/g)
No effect	7.0 (5.5–10.5)	10.0 (8.5–14.0)
50%	13.0 (10.0–17.0)	15.0 (11.0–19.0)
90%	17.0 (12.0–22.0)	18.0 (12.5–23.0)

Range is reported in parentheses following the point estimate.

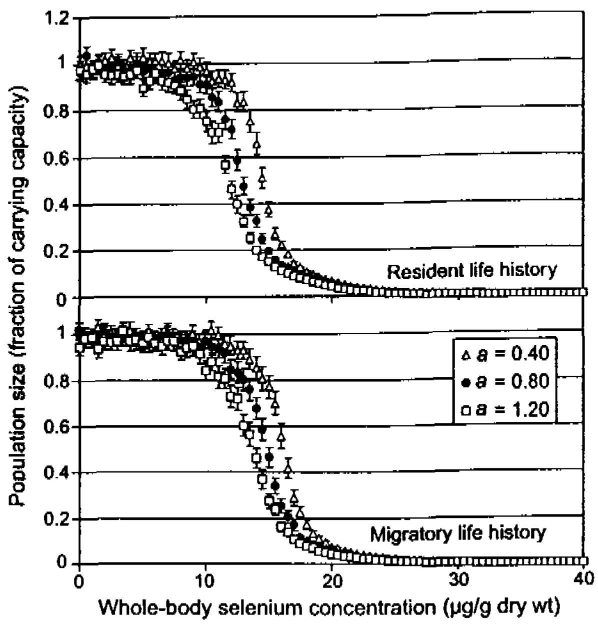

Fig. 6 – Sensitivity of mean population-level selenium response to the juvenile survival function parameter *a*. All simulations used the expected values of toxicity response functions (Fig. 3). Each datum is the mean of 100 values, one randomly selected from each of 100 independent stochastic simulations. Error bars show the 95% CI for the mean.

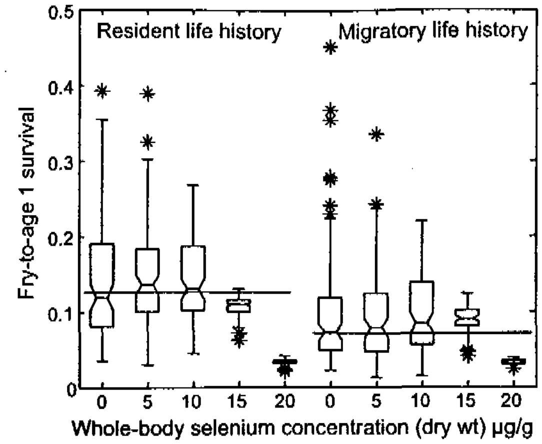

Fig. 8 – Fry-to-age 1 survival as a function of whole-body selenium concentration using *a* = 0.80 and expected values of toxicity response (Fig. 3). Each plot summarizes 100 values, one randomly selected from each of 100 independent stochastic simulations. Horizontal lines show fry-to-age 1 survival necessary to maintain population at equilibrium in a constant environment. Notches depict results of a Kruskal–Wallis test for equality of medians. Non-overlap of notches indicates significant difference in medians.

lation growth rate to toxicity-induced changes in demographic parameters depends on whether it is measured at low population densities, where *r* is likely to be near its maximum, or under equilibrium conditions, where *r* is likely to be near zero (Forbes and Calow, 1999; Forbes et al., 2001). Our results illustrate the importance of distinguishing between low-density

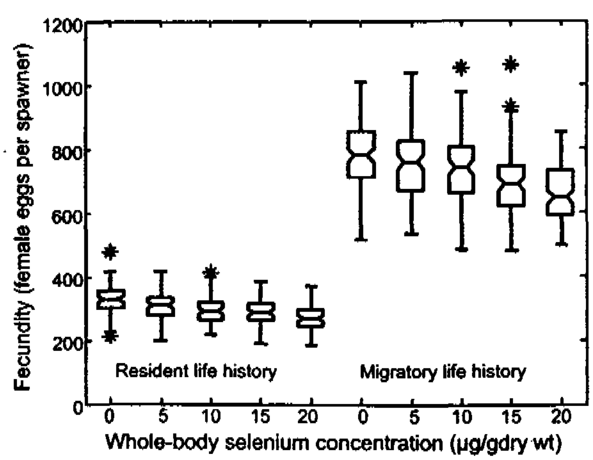

Fig. 7 – Fecundity as a function of whole-body selenium concentration using *a* = 0.80 and expected values of toxicity response (Fig. 3). Each plot summarizes 100 values, one randomly selected from each of 100 independent stochastic simulations. Notches depict results of a Kruskal–Wallis test for equality of medians. Non-overlap of notches indicates significant difference in medians.

and equilibrium growth rates when assessing and reporting the effect of toxicant exposure on population growth rate. Even under very high toxicant concentrations, our simulated populations re-established stable equilibria after a period of about 3–13 generations (Fig. 4), but these new equilibria were significantly lower than carrying capacity. Similarly, using a deterministic matrix model of population growth in westslope cutthroat trout (*O. c. lewisii*), Spromberg and Birge (2005) observed that reductions in vital rates due to toxicant exposure resulted in a period of population decline followed by re-stabilization of the population at a new equilibrium that was lower than that of an unexposed reference population. In both of these cases, the equilibrium population *growth rate* was unaffected by toxicant exposure, whereas the equilibrium population *size* was reduced.

A second important result from our simulations is that because of strong density-dependence in juvenile survival, cutthroat trout populations have the capacity to compensate for increased toxicity-related mortality, as long as mortality remains below some critical level. Although few investigators have directly addressed population response to toxicant exposure under density-dependent conditions, three modeling studies have shown similar results, namely that populations exhibiting density dependence were able to compensate for decreased demographic rates in early life stages (Grant, 1998; Hansen et al., 1999; Spromberg and Birge, 2005). However, the cutthroat trout populations we modeled were able to compensate for selenium-induced mortality because this additional mortality occurred prior to the density-dependent effects. If density-dependent mortality occurred in juvenile cutthroat trout not during the winter but rather during spring or summer, as has been observed in a migratory population of brown

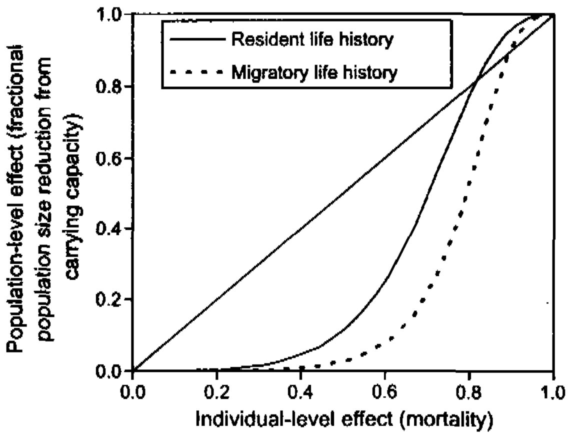

Fig. 9 – Dependence of mean population-level effect on mean individual-level effect. Population-level effects were calculated from non-linear least-squares logistic functions fit to the mean population size data shown in Fig. 5. Individual-level effects were computed from the mean mortality curve in Fig. 3.

trout (*Salmo trutta*, Elliott, 1989), this compensatory ability would be greatly reduced, if not lost completely.

Of the two individual-level effects included in our model, juvenile mortality was a much stronger determinant of population response than was fecundity (Figs. 7 and 8). Hence, the relationship between mortality and population-level response, as measured by percent decrease from carrying capacity, is a good approximation to the relationship between individual and population effects. This relationship (Fig. 9) shows that population-level effects were lower than individual-level effects until mortality exceeded 82% for the resident life history and 90% for the migratory life history. Migratory populations showed greater ability to compensate for juvenile mortality because longer life spans and higher individual growth rates (Table 2) result in spawners of larger body sizes and hence greater fecundities than those of resident populations (Fig. 7). This observation illustrates that variations in life history can greatly influence the response of populations to toxicant exposure, even when individual-level effects are held fixed, as has been observed in other models (Hansen et al., 1999; Spromberg and Birge, 2005). In contrast with our results, Spromberg and Birge (2005) predicted that fish populations with longer life spans and reliance on older individuals for reproduction were more sensitive to the effects of toxicant exposure. However, their model did not incorporate increase in fecundity with spawner age or size, which is the primary mechanism responsible for decreased population-level response to toxicant exposure in our migratory life history type.

Although simple in concept, the compensatory ability afforded by high fecundities relative to the number of eventual age-1 survivors needed to sustain the population may be mechanistically complex in a variable environment. For example, in the absence of environmental stochasticity, resident populations required an average fry-to-age 1 survival of 0.126 to maintain the population at equilibrium (Fig. 8). In simulated resident populations with selenium concentrations of 10 μg/g, median juvenile survival was 0.129 (not significantly different than that in unexposed populations, Fig. 8), but long-term population size was 90.8% of (and significantly less than) carrying capacity (Fig. 5). This observation is partly explained by decreased reproduction, which is due to decreases in size-related fecundity (Fig. 7). If fewer juveniles are produced, fewer will succumb to density-dependent mortality, and thus average survival will stay the same or possibly even increase.

However, even after accounting for reduction in fecundity and increase in mortality due to selenium exposure in this example, average fecundity and juvenile survival were sufficient to maintain an equilibrium population size of 0.974 in a constant environment. This deterministic population size is significantly higher than the mean population size of 0.908 observed in the stochastic model. Although median juvenile survival at 10 μg/g was not significantly less than that at 0 μg/g, survival rates exceeding 25% occurred much less frequently at 10 μg/g than at 0 μg/g (Fig. 8). These results suggest that in a stochastic environment, equilibrium population size is maintained at carrying capacity not via sufficient average survival rates but rather through the potential for well-above-average survival rates to occur when fry production is low relative to habitat availability. These simulation results corroborate the field observations of Mitro et al. (2003, increased survivorship when environmental conditions are favorable) and Magee et al. (1996, increased survivorship when fry production is low). Although other authors have identified environmental stochasticity as an important determinant of population-level response (Ferson et al., 1996; Spromberg and Birge, 2005), our review of the literature did not reveal any studies incorporating stochasticity into models of toxicant effects.

4.2. *Application to protection of cutthroat trout*

Based on the more sensitive resident life history form, our recommended maximum allowable concentration in whole-body fish tissue to protect cutthroat trout in the upper Snake River basin is 7.0 μg/g. Values that have been proposed based on individual-level effects are somewhat lower: 4 μg/g for freshwater fish in general (Lemly, 1993a; Hamilton, 2003), and 6 μg/g for juvenile anadromous salmonids (DeForest et al., 1999). A more conservative estimate based on our results is the 5.5 μg/g value that forms the lower end of the range for our point estimate. In either case, our estimates are somewhat less than USEPA's proposed criterion of 7.91, which is based on an analysis of Lemly's (1993b) winter study on bluegills. A version of our model applied to this warm-water species would provide a more relevant figure for comparison with USEPA's proposed criterion. A recent review concluded that the proposed 7.91 μg/g is also protective of cold-water fish species (Chapman, 2007), but this conclusion was based only on the effects of selenium exposure on reproduction and not on its effects on juvenile mortality and growth. Our model shows that reductions in juvenile growth and survival may result in significant population declines at 7.91 μg/g even in absence of decreased reproduction.

Our review of all publicly available information on salmonid fish-tissue selenium concentrations in the Blackfoot and Salt river drainages yielded a set of 63 observations, with a

geometric mean of 9.81 μg/g (range 1.8–52.3 μg/g; Hamilton et al., 2002; Hamilton and Buhl, 2003, 2004; unpublished Research Triangle Institute Reports to Greater Yellowstone Coalition, 2005, 2006). Although these data were not collected in a manner that allows statistical inference, they do show that selenium concentrations in some locations are high enough to cause significant population declines in cutthroat trout of both life history forms. A statistically rigorous field study of selenium concentrations and fish population sizes in the Blackfoot and Salt river drainages is required to determine whether population declines are occurring, as we predict based on model results and these observed concentrations.

Among all Yellowstone cutthroat trout populations in their native range in eastern Idaho, those of the Salt and Blackfoot watersheds are the largest and third-largest, respectively, and exist in large, well-connected meta-populations consisting primarily of migratory subpopulations (Meyer et al., 2006). Upper bounds on estimates of effective population sizes in the Salt and Blackfoot watersheds are 41,289 and 2415, respectively (Meyer et al., 2006). Because of their large body size and primarily migratory life history, these watershed-scale metapopulations are not likely to go extinct unless selenium concentrations across the watershed exceed means of 17–20 μg/g, enough to reduce the effective population sizes, N_e, to 500, below which theoretical models predict populations can not maintain the genetic diversity necessary for long-term adaptation (Rieman et al., 1993). On the other hand, the migratory nature of these populations means that the majority of spawning and juvenile residence is occurring in headwater areas where mining, and hence the potential for selenium contamination, occurs. Thus, migration may act as a mechanism to expose these large, watershed-scale populations to the effects of toxicity because the most sensitive life stage occurs where contamination potential is highest. This could result in decreases in adult population sizes in mainstem rivers or reservoirs far downstream from streams directly affected by contamination.

We should emphasize that our model underestimated effects of selenium on cutthroat trout populations because it included effects only on pre-winter juvenile growth and survival and not effects that have been observed in numerous other life stages of warm-water fish and could also occur in trout (Table 1). In particular, effects of selenium toxicity on winter survival in salmonids has not been investigated, and the population-level effects of selenium toxicity on cutthroat trout could be substantially greater than we have predicted if the winter stress syndrome observed by Lemly (1993b) in bluegills is also experienced by salmonids. More data on individual-level effects of selenium toxicity to salmonid fishes are required to refine our predictions.

Furthermore, our model does not account for the presence of non-native trout, which have been implicated in widespread decline of native cutthroat trout throughout their range (Behnke, 1992) and which are abundant in the Blackfoot and Salt river watersheds (Meyer et al., 2003b, 2006). Juvenile cutthroat trout survival can be significantly lower in the presence of non-native trout than in allopatry because of the size advantage the non-native trout bring to the competition for winter habitat (Gregory and Griffith, 2000; Peterson et al., 2004; Koenig, 2006). This additional layer of mortality could increase the population-level response in cutthroat trout at a given selenium concentration.

4.3. *Implications for assessment, management and regulation*

Our results have three important implications for assessment and management of populations exposed to toxicants and for the regulation of activities that produce these toxicants. First, regulatory criteria and risk assessments based on individual-level effects may not be relevant at the population level. In populations exhibiting density dependence, population-level effects may be much lower than individual-level effects at low-to-moderate toxicant concentrations. However, once individual effects become large enough to outweigh the population's inherent compensatory mechanism, the population-level effect can increase sharply over a relatively small range of toxicant concentrations and associated individual-level effects (Figs. 5 and 9). Second, long-term population size may yield more information about response to toxicant exposure than population growth rate. For example, population assessments performed after the initial period of decline that is illustrated in Fig. 4 may show no significant reduction in growth rate relative to unexposed populations, leading to an incorrect conclusion of no effect, even though population size has been significantly decreased relative to that of unexposed populations. Third, assessments, regulatory mechanisms, and management actions must account for environmental variability. In particular, average values of demographic parameters should not be used in population-level assessments. Observation of average demographic rates sufficient to maintain populations at carrying capacity in the absence of toxic effects or environmental variability is not sufficient to conclude no toxic effect on population size. Population persistence in variable environments may depend less on long-term average survival rates than on the capacity for high juvenile survival in the infrequently occurring years when production is low relative to habitat availability. Mechanistically then, the ultimate population-level effect of the toxicant may not be reduction of mean values of demographic parameters but rather reduction of population resilience to environmental stochasticity, realized through reduction in the variance of demographic parameters.

4.4. Conclusion

We have demonstrated that stochastic simulation modeling can be a useful tool in predicting population-level response to a toxicant based on effects to individuals. Although applied here to selenium and cutthroat trout with whole-body tissue concentration as the toxicity metric, the methods we have presented are applicable to nearly any toxicant, organism, and metric. The necessary ingredients are knowledge of life cycles and associated demographic parameters and toxicological data sufficient to allow statistical estimation of response functions for individual-level effects. Laboratory experiments that generate toxicological data need to include treatments at toxicant concentrations sufficient to elicit responses of at least 50% in order to allow logistic or other sigmoidal functions to be determined with high statistical significance levels

and narrow CIs. Experiments showing no toxic effects are useful only if treatments include concentrations equal to the highest values likely to be experienced in the environment (e.g., 40–50 μg/g in our example). Where toxicological data are missing, the modeling process can identify these gaps (e.g., effects of selenium on winter juvenile survival in salmonids in our case), and once the basic life cycle is modeled, new toxicological results can easily be incorporated as they become available. Similarly, additional individual-level behavior can be incorporated into the life-cycle model. In our application, sufficient data were available to model density dependence in juvenile winter survival, which allowed identification of mechanisms linking juvenile mortality and population size. Incorporation of further detail at the individual-level (e.g., density-dependent competition among juveniles for food during the summer) would allow tests of other mechanisms that could affect population-level response. We believe that stochastic population simulation should become a standard tool in ecotoxicology that can inform assessment and regulation in site/toxicant/species-specific cases as well as generate new understanding of mechanisms affecting the relationship between individual- and population-level responses to toxicant exposure.

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REFERENCES

Behnke, R.J., 1992. Native trout of western North America. Am. Fish. Soc. Monogr. No. 6. Bethesda, Maryland.

Bowie, G.L., Sanders, J.G., Riedel, G.F., Gilmour, C.C., Breitburg, D.L., Cutter, G.A., Porcella, D.B., 1996. Assessing selenium cycling and accumulation in aquatic ecosystems. Water Air Soil Pollut. 90, 105–112.

Calow, P., Sibley, R.M., Forbes, V., 1997. Risk assessment on the basis of simplified life-history scenarios. Environ. Toxicol. Chem. 16, 1983–1989.

Canton, S.P., VanDerveer, W.D., 1997. Selenium toxicity to aquatic life: an argument for sediment-based water quality criteria. Environ. Toxicol. Chem. 16, 1255–1259.

Chapman, P.M., 2007. Selenium thresholds for fish from cold freshwaters. Hum. Ecol. Risk Assess. 13, 20–24.

Coughlan, D.J., Velte, J.S., 1989. Dietary toxicity of selenium-contaminated red shiners to striped bass. Trans. Am. Fish. Soc. 118, 400–408.

Coyle, J.J., Buckler, D.R., Ingersoll, C.G., Fairchild, J.F., May, T.W., 1993. Effect of dietary selenium on the reproductive success of bluegills (*Lepomis macrochirus*). Environ. Toxicol. Chem. 12, 551–565.

DeForest, D.K., Brix, K.V., Adams, W.J., 1999. Critical review of proposed residue-based selenium toxicity thresholds for freshwater fish. Hum. Ecol. Risk Assess. 5, 1187–1228.

Dennis, B., Munholland, P.L., Scott, J.M., 1991. Estimation of growth and extinction parameters for endangered species. Ecol. Monogr. 61, pp. 115–143.

Dobbs, M.G., Cherry, D.S., Cairns, J., 1996. Toxicity and bioaccumulation of selenium in a three-trophic level food chain. Environ. Toxicol. Chem. 15, 340–347.

Elliott, J.M., 1989. Mechanisms responsible for population regulation in your migratory trout *Salmo trutta*. I. The critical time for survival. J. Anim. Ecol. 58, 987–1001.

Ferson, S., Ginzburg, L.R., Goldstein, R.A., 1996. Inferring ecological risk from toxicity bioassays. Water Air Soil Pollut. 90, 71–82.

Forbes, V.E., Calow, P., 1999. Is the per capita rate of increase a good measure of population-level effects in ecotoxicology? Environ. Toxicol. Chem. 18, 1544–1556.

Forbes, V.E., Sibley, R.M., Calow, P., 2001. Toxicant impacts on density-limited populations: a critical review of theory, practice, and results. Ecol. Appl. 11, 1249–1257.

Garcia-Hernandez, J., Glenn, E.P., Artiola, J., Baumgartner, D.J., 2000. Bioaccumulation of selenium (Se) in the Cienega de Santa Clara wetland, Sonora, Mexico. Ecotoxicol. Environ. Saf. 46, 298–304.

Gillespie, R.B., Baumann, P.C., 1986. Effects of high tissue concentrations of selenium on reproduction by bluegills. Trans. Am. Fish. Soc. 115, 208–213.

Gissell Nielsen, M., Gissel-Nielsen, G., 1978. Sensitivity of trout to chronic and acute exposure to selenium. Agric. Environ. 4, 85–91.

Goettl, J.P., Davies, P.H., 1978. Water Pollution Studies. Job Progress Report F-33-R-13. Colorado Division of Wildlife, Denver.

Goodman, D., 1987. The demography of chance extinction. In: Soule, M.E. (Ed.), Viable Populations for Conservation. Cambridge University Press, Cambridge, pp. 11–34.

Grant, A., 1998. Population consequences of chronic toxicity: incorporating density dependence into the analysis of life table experiments. Ecol. Modell. 105, 325–335.

Gregory, J.S., 2000. Winter fisheries research and habitat improvements on the Henry's Fork of the Snake River. Intermountain J. Sci. 6, 232–248.

Gregory, J.S., Griffith, J.S., 2000. First-winter survival of caged wild and hatchery cutthroat trout in allopatry and in sympatry with brook trout. Intermountain J. Sci. 6, 217–222.

Haddon, M., 2001. Modelling and Quantitative Methods in Fisheries. Chapman and Hall/CRC Press, Boca Raton, FL.

Hamilton, S.J., 2002. Rationale for a tissue-based selenium criterion for aquatic life. Aquat. Toxicol. 57, 85–100.

Hamilton, S.J., 2003. Review of residue-based selenium toxicity thresholds for freshwater fish. Ecotoxicol. Environ. Saf. 56, 201–210.

Hamilton, S.J., Wiedmeyer, R.H., 1990. Concentrations of boron, molybdenum, and selenium in Chinook salmon. Trans. Am. Fish. Soc. 119, 500–510.

Hamilton, S.J., Buhl, K.J., 2003. Selenium and other trace elements in water, sediment, aquatic plants, aquatic invertebrates and fish from streams in southeastern Idaho near phosphate mining operations, May 2001. U.S. Geological Survey. Columbia Environmental Research Center, Yankton, SD.

Hamilton, S.J., Buhl, K.J., 2004. Selenium in water, sediment, plants, invertebrates, and fish in the Blackfoot River drainage. Water Air Soil Pollut. 159, 3–34.

Hamilton, S.J., Palmisano, A.N., Wedemeyer, G.A., Yasutake, W.T., 1986. Impacts of selenium on early life stages and smoltification of fall Chinook salmon. Trans. N. Am. Wildl. Nat. Resour. Conf. 51, 343–356.

Hamilton, S.J., Buhl, K.J., Faerber, N.L., Wiedmeyer, R.H., Bullard, F.A., 1990. Toxicity of organic selenium in the diet to Chinook salmon. Environ. Toxicol. Chem. 9, 347–358.

Hamilton, S.J., Buhl, K.J., Lamothe, P.J., 2002. Selenium and other trace elements in water, sediment, aquatic plants, aquatic invertebrates and fish from streams in southeastern Idaho near phosphate mining operations, June 2000. U.S. Geological

Survey. Columbia Environmental Research Center, Yankton, SD.

Hamilton, S.J., Buhl, K.J., Lamothe, P.J., 2004. Selenium and other trace elements in water, sediment, aquatic plants, aquatic invertebrates, and fish from streams in SE Idaho near phosphate mining. In: Hein, J.R. (Ed.), Life Cycle of the Phosphoria Formation: from Deposition to the Post-Mining Environment. Handbook of Exploration, Environmental Geochemistry, vol. 8. In: Hale, M. (Series Ed.). Elsevier, Amsterdam, pp. 483–535.

Hansen, F., Forbes, V.E., Forbes, T.L., 1999. Using elasticity analysis of demographic models to link toxicant effects on individuals to the population level: an example. Funct. Ecol. 13, 157–162.

Hardy, R.W., 2005. Effects of dietary selenium on cutthroat trout (*Oncorhynchus clarki*) growth and reproductive performance. Report Prepared for Montgomery Watson Harza. Bellevue, WA.

Hermanutz, R.O., Allen, K.N., Roush, T.H., Hedtke, S.F., 1992. Effects of elevated selenium concentrations on bluegills (*Lepomis macrochirus*) in outdoor experimental streams. Environ. Toxicol. Chem. 11, 217–224.

Hicks, B.D., Hilton, J.W., Ferguson, H.W., 1984. Influence of dietary selenium on the occurrence of nephrocalcinosis in the rainbow trout *Salmo gairdneri* Richardson. J. Fish Dis. 7, 379–389.

Hilderbrand, R.H., 2003. The roles of carrying capacity, immigration, and population synchrony on persistence of stream-resident cutthroat trout. Biol. Conserv. 110, 257–266.

Hilton, J.W., Hodson, P.V., 1983. Effect of increased dietary carbohydrate on selenium metabolism and toxicity in rainbow trout (*Salmo gairdneri*). J. Nutr. 113, 1241–1248.

Hilton, J.W., Hodson, P.V., Slinger, S.J., 1980. The requirement and toxicity of selenium in rainbow trout (*Salmo gairdneri*). J. Nutr. 110, 2527–2535.

Hodson, P.V., Spry, D.J., Blunt, B.R., 1980. Effects on rainbow trout (*Salmo gairdneri*) of a chronic exposure to waterborne selenium. Can. J. Fish. Aquat. Sci. 37, 233–240.

Holm, J., Palace, V., Siwik, P., Sterling, G., Evans, R., Baron, C., Werner, J., Wautier, K., 2005. Developmental effects of bioaccumulated selenium in eggs and larvae of two salmonid species. Environ. Toxicol. Chem. 24, 2373–2381.

Hunn, J.B., Hamilton, S.J., Buckler, D.R., 1987. Toxicity of sodium selenite to rainbow trout fry. Water Res. 21, 233–238.

Jager, T., Crommentuijn, T., Van Gestel, C.A.M., Kooijman, S.A.L.M., 2004. Simultaneous modeling of multiple end points in life-cycle toxicity tests. Environ. Sci. Technol. 38, 2894–2900.

Jasinski, S.M., Lee, W.H., Causey, J.D., 2004. The history of production of the western phosphate field. In: Hein, J.R. (Ed.), Life Cycle of the Phosphoria Formation: from Deposition to the Post-mining Environment. Handbook of Exploration and Environmental Geochemistry, vol. 8. In: Hale, M. (Series Ed.). Elsevier, Amsterdam, pp. 45–71.

Kennedy, C.J., McDonald, L.E., Loveridge, R., Strosher, M.M., 2000. The effect of bioaccumulated selenium on mortalities and deformities in the eggs, larvae, and fry of a wild population of cutthroat trout (*Oncorhynchus clarki lewisi*). Arch. Environ. Contam. Toxicol. 39, 46–52.

Kiefling, J.W., 1978. Studies on the Ecology of the Snake River Cutthroat Trout. Fisheries Technical Bulletin No. 3. Wyoming Game and Fish Department, Cheyenne, WY.

Koenig, M.K., 2006. Habitat and biotic factors influencing distribution and recruitment of juvenile cutthroat trout in the Teton River, Idaho. M.S. Thesis. Utah State University, Logan, UT.

Kooijman, S.A.L.M., Metz, J.A.J., 1984. On the dynamics of chemically stressed populations: the deduction of population consequences from effects of individuals. Ecotoxicol. Environ. Saf. 8, 254–274.

Kuhn, A., Munns Jr., W.R., Poucher, S., Champlin, D., Lassier, S., 2000. Prediction of population-level response from mysid toxicity test data using population modeling techniques. Environ. Toxicol. Chem. 19, 2364–2371.

Lemly, A.D., 1993a. Guidelines for evaluating selenium data from aquatic monitoring and assessment studies. Environ. Monit. Assess. 28, 83–100.

Lemly, A.D., 1993b. Metabolic stress during winter increases the toxicity of selenium to fish. Aquat. Toxicol. 27, 133–158.

Lemly, A.D., 1999. Selenium transport and bioaccumulation in aquatic ecosystems: a proposal for water quality criteria based on hydrological units. Ecotoxicol. Environ. Saf. 42, 150–156.

Lemly, A.D., 2002. Symptoms and implication of selenium toxicity in fish: the Belews Lake case examples. Aquat. Toxicol. 57, 39–49.

Lemly, A.D., 2004. Aquatic selenium pollution is a global environmental safety issue. Ecotoxicol. Environ. Saf. 59, 44–56.

Magee, J.P., McMahon, T.E., Thurow, R.F., 1996. Spatial variation in spawning habitat of cutthroat trout in a sediment-rich stream basin. Trans. Am. Fish. Soc. 125, 768–779.

Maier, K.J., Nelson, C.R., Bailey, F.C., Klaine, S.J., Knight, A.W., 1998. Accumulation of selenium in the aquatic biota of a watershed treated with seleniferous fertilizer. Bull. Environ. Contam. Toxicol. 60, 409–416.

Meyer, K.A., Schill, D.J., Elle, F.S., Lamansky Jr., J.A., 2003a. Reproductive demographics and factors that influence length at sexual maturity of Yellowstone cutthroat trout in Idaho. Trans. Am. Fish. Soc. 132, 183–195.

Meyer, K.A., Schill, D.J., Elle, F.S., Schrader, W.C., 2003b. A long-term comparison of Yellowstone cutthroat trout abundance and size structure in their historical range in Idaho. N. Am. J. Fish. Manage. 23, 149–162.

Meyer, K.A., Schill, D.J., Lamansky Jr., J.A., Campbell, M.R., Kozfkay, C.C., 2006. Status of Yellowstone cutthroat trout in Idaho. Trans. Am. Fish. Soc. 135, 1329–1347.

Mitro, M.G., Zale, A.V., 2002. Seasonal survival, movement, and habitat use of age-0 rainbow trout in the Henry's Fork of the Snake River, Idaho. Trans. Am. Fish. Soc. 131, 271–286.

Mitro, M.G., Zale, A.V., Rich, B.A., 2003. The relation between age-0 rainbow trout (*Oncorhynchus mykiss*) abundance and winter discharge in a regulated river. Can. J. Fish. Aquat. Sci. 60, 135–139.

Ogle, R.S., Knight, A.W., 1989. Effects of elevated foodborne selenium on growth and reproduction of the fathead minnow (*Pimephales promelas*). Arch. Environ. Contam. Toxicol. 18, 795–803.

Péry, A.R.R., Geffard, A., Garric, J., 2006. Mechanistic models to perform population risk assessment with the midge *Chironomus Riparius*: application to heavy metals. Environ. Sci. Technol. 40, 6026–6031.

Peterson, D.P., Fausch, K.D., White, G.C., 2004. Population ecology of invasion: effects of brook trout on native cutthroat trout. Ecol. Appl. 14, 754–772.

Presser, T.S., Sylvester, M.A., Lew, W.H., 1994. Bioaccumulation of selenium from natural geologic sources in western states and its potential consequences. Environ. Manage. 18, 423–436.

Presser, T.S., Hardy, M., Huebner, M.A., Lamothe, P.J., 2004. Selenium loading through the Blackfoot River watershed: linking sources to ecosystems. In: Hein, J.R. (Ed.), Life Cycle of the Phosphoria Formation: from Deposition to the Post-mining Environment. Handbook of Exploration and Environmental Geochemistry, vol. 8. In: Hale, M. (Series Ed.). Elsevier, Amsterdam, pp. 437–466.

Rieman, B., Lee, D., McIntyre, J., 1993. Consideration of Extinction Risks for Salmonids, Fish Habitat Relationships Technical Bulletin No. 14. USDA Forest Service Intermountain Research Station, Boise, ID.

Roex, E.W.M., Van Gestel, C.A.M., Van Wezel, A.P., Van Straalen, N.M., 2000. Ratios between acute toxicity and effects on population growth rates in relation to toxicant mode of action. Environ. Toxicol. Chem. 19, 685–693.

Seiler, R.L., 1998. Prediction of lands susceptible to irrigation-induced selenium contamination water. In: Frankenberger Jr., W.T., Engberg, R.A. (Eds.), Environmental Chemistry of Selenium. Marcel Dekker, New York, pp. 397–418.

Skorupa, J.P., 1998. Selenium poisoning of fish and wildlife in nature: lessons from twelve real-world examples. In: Frankenberger Jr., W.T., Engberg, R.A. (Eds.), Environmental Chemistry of Selenium. Marcel Dekker, New York, pp. 315–354.

Snell, T.W., Serra, M., 2000. Using probability of extinction to evaluate the ecological significance of toxicant effects. Environ. Toxicol. Chem. 19, 2357–2363.

Spromberg, J.A., Birge, W.J., 2005. Modeling the effects of chronic toxicity on fish populations: the influence of life-history strategies. Environ. Toxicol. Chem. 24, 1532–1540.

Spromberg, J.A., Meador, J.P., 2005. Relating results of chronic toxicity responses to population-level effects: modeling effects on wild Chinook salmon populations. Integr. Environ. Assess. Manage. 1, 9–21.

Spromberg, J.A., Meador, J.P., 2006. Relating chronic toxicity responses to population-level effects: a comparison of population-level parameters for three salmon species as a function of low-level toxicity. Ecol. Modell. 199, 240–252.

Stark, J.D., 2005. How closely do acute lethal concentration estimates predict effects of toxicants on populations? Integr. Environ. Assess. Manage. 1, 109–113.

Stark, J.D., Vargas, R.I., 2005. Toxicity and hazard assessment of fipronil to *Daphnia pulex*. Ecotoxicol. Environ. Saf. 62, 11–16.

Thurow, R.F., Corsi, C.E., Moore, V.K., 1988. Status, ecology, and management of Yellowstone cutthroat trout in the upper Snake River drainage, Idaho. Am. Fish. Soc. Symp. 4, 25–36.

U.S. Environmental Protection Agency (USEPA), 2004. Notice of draft aquatic life criteria for selenium and request for scientific information, data, and views. Federal Register 69, 75541–75546.

U.S. Fish and Wildlife Service (USFWS), 2006. Endangered and threatened wildlife and plants; 12-month finding for a petition to list the Yellowstone cutthroat trout as threatened. Federal Register 71, 8818–8831.

Varley, J.D., Gresswell, R.E., 1988. Ecology, status and management of the Yellowstone cutthroat trout. Am. Fish. Soc. Symp. 4, 13–24.

Walthall, W.K., Stark, J.D., 1997. Comparison of two population-level ecotoxicological endpoints: the intrinsic (r_m) and instantaneous (r_i) rates of increase. Environ. Toxicol. Chem. 16, 1068–1073.

Woock, S.E., Garrett, W.R., Partin, W.E., Bryson, W.T., 1987. Decreased survival and teratogenesis during laboratory selenium exposures to bluegill *Lepomis macrochirus*. Bull. Environ. Contam. Toxicol. 39, 998–1005.

EXHIBIT B

Appendix 3B

Spawning Gravel Requirements for Cutthroat Trout

Spawning Gravel Requirements for Cutthroat Trout
Technical Memo

1.0 Introduction

Cutthroat trout spawn under specific stream conditions related to water temperature, substrate (gravel) characteristics, and other physical cues (e.g., water velocity). Female salmonids construct nests by first clearing away fine sediment to create a pocket that contains less sediment than the surrounding gravel (Hartman & McMahon 2004). Sediment intrusion into the nest can reduce intra-gravel permeability, thereby limiting the supply of oxygen to developing embryos (Reiser & White 1988). Numerous early (pre-1970) field and laboratory studies established that the amount of "fines" or fine sediments (usually < 6 mm in diameter) in spawning gravel is directly related to embryo mortality (reviewed in Chapman 1988), and the requirements of spawning trout (most often steelhead or rainbow) with regard to precise sediment content in gravel have since been studied extensively.

2.0 Cutthroat trout

Thurow and King (1994) first described the spawning requirements of Yellowstone cutthroat trout in southeast Idaho with regard to precise sediment content. They characterized spawning sites of Yellowstone cutthroat trout in a Snake River tributary (Pine Creek, southeast Idaho) and found that, on average, 20% of the gravel substrate was smaller than 6.35 mm and 5% was less than 0.85 mm. In general, cutthroat trout in their study spawned over substrate with a wider range of particle sizes (0.06-100 mm in diameter) than those found in the literature (Thurow & King 1994). Other studies (cited in Thurow & King) find that cutthroat prefer gravels from 19-76 mm (Cope 1957), 12-85 mm (Varley & Gresswell 1988), or 15-60 mm (Hickman & Raleigh 1982).

3.0 Other trout species in Idaho

Studies of other trout in Idaho add to the consensus that embryo survival is indirectly related to the percentage of fine sediment in spawning gravel, and at similar levels as were found for the Snake River Yellowstone cutthroat. McCuddin (1977) found steelhead survival in natural spawning areas decreased as the proportion of sand in the substrate increased above 10-20%. In that study, any percentage of 6-12 mm particles above 10-15% appeared to reduce survival, as did any percentage of fines (<6 mm) above about 20-25% (McCuddin 1977 *cited in Chapman 1988*). Reiser and White (1988) found a similar threshold for fine sediments. They incubated steelhead trout eggs in 16 mixtures of fine (<0.84 mm) and coarse (0.84-4.6 mm) sediments (representative of those found in the Idaho batholith) into laboratory gravel nests and found that embryos were more sensitive to increases in fines (<0.84 mm). They found a ratio of 30% fine sediment (and 70% gravel) was generally the lethal limit for steelhead embryos. Using sediments "imported" from streams in central Idaho, Tappel and Bjornn (1983) found that 90-93% of the variability in steelhead embryo survival (in the laboratory) was correlated negatively to the percentage of two different particle sizes in gravel: sediment less than 0.85 mm and sediment less than 9.5 mm in diameter, thus medium-sized sediment may also play an important role in survival of some species.

4.0 References

Chapman, D. W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Transactions of the American Fisheries Society 117(1): 1-21.

Cope, O. B. 1957. The choices of spawning sites by cutthroat trout. Proceedings of the Utah Academy of Arts and Sciences, Arts, and Letters 34: 73-79. *Cited in Thurow & King 1994*

Hartman, G. F., and T. E. McMahon. 2004. "Aspects of fish reproduction and some implications of forestry activities." In Fishes and Forestry: Worldwide Watershed Interactions and Management, eds. T. G. Northcote and G. F. Hartman. Blackwell Science.

Hickman, T., and R. F. Raleigh. 1982. Habitat suitability index models: cutthroat trout. US Fish and Wildlife Service, Habitat Evaluation Procedures Group, Western Energy and Land Use Team. Fort Collins, Colorado. *Cited in Thurow & King 1994*

McCuddin, M. E. 1977. Survival of salmon and trout embryos and fry in gravel-sand mixtures. Master's Thesis. University of Idaho, Moscow, Idaho. *Cited in Chapman 1988*

Reiser, D. W., and R. G. White. 1988. Effects of two sediment size-classes on survival of steelhead and chinook salmon eggs. North American Journal of Fisheries Management 8: 432-437.

Tappel, P. D., and T. C. Bjornn. 1983. A new method of related size of spawning gravel to salmonid embryo survival. North American Journal of Fisheries Management 3:123-135.

Thurow, R. F., and J. G. King. 1994. Attributes of Yellowstone cutthroat trout redds in a tributary of the Snake River, Idaho. Transactions of the American Fisheries Society 123: 37-50.

Varley, J. D., and R. E. Gresswell. 1988. Ecology, status, and management of the Yellowstone cutthroat trout. American Fisheries Society Symposium 4: 13-24. *Cited in Thurow & King 1994*

EXHIBIT C

Comments of

Greater Yellowstone Coalition

Natural Resources Defense Council

Caribou Clean Water Partnership

and

Idaho Conservation League

on

Smoky Canyon Mine, Panels F & G Expansion

Final Environmental Impact Statement

Prepared by

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December 21, 2007

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APPENDICES

I. Introduction

Lying along the southwestern edge of the Greater Yellowstone Ecosystem, the mountains of eastern Idaho are home to a diversity of wildlife including moose, elk, gray wolf, great gray owls, goshawks, Yellowstone cutthroat, and many more. Many of these species migrate throughout the Yellowstone ecosystem and beyond. These mountains were once summer gathering areas for early Native Americans and are now home to many growing communities, diverse industries and thriving businesses. The mountains also contain reserves of many natural resources of increasing national and global importance. Among the premier resources found here are the vast tracts of roadless, forest land managed by the Caribou-Targhee National Forest. These wild and remote places are widely recognized for their biological diversity, their critical habitat and their contribution to life-giving sources of clean water.

The mountains of eastern Idaho collect the snows each winter. In turn the winter snows help sustain the network of seeps, springs, and creeks forming the headwaters to the Portneuf, Bear, Blackfoot, Snake and Salt Rivers. Melting snows create the streams and rivers that provide crucial water supplies for the Great Basin and across the Snake River Plains, supporting the communities, ranches and farms of the region. Because of these water supplies, each year thousands of locals and visitors from around the world hunt, camp, fish, and enjoy other outdoor activities in these pristine mountains.

Local people and visitors from around the globe treasure the unique aspects of these lands. On his second hunting and fishing trip to the area New Zealand hunting and fishing guide, Vern Wilson, stated, "I've traveled much of the world and have seen few places that rival the Caribou National Forest for diversity of wildlife and terrain, and the trout in these streams rival the much touted trout of my New Zealand home." Government resource managers too have recognized the special values of the area. For example, in 1998, Jerry Reese, then supervisor of the Caribou-Targhee National Forest, stated in a letter to the then state BLM Director Martha Hahn: "Because of the sensitive nature and the importance of the surface resources present in Deer Creek and North Fork Deer Creek drainages, we strongly recommend against any phosphate leasing now or in the foreseeable future."[1]

Concerned over threats to the region's scenic beauty and environmental treasures – its clean air and water, its sense of tranquility, its expansive forests and its blue ribbon trout streams, many local individuals, businesses and groups have joined together to form the Caribou Clean Water Partnership to protect the diminishing resources of the area. Many of the partnership members have special links to this unique place. Dr. Steve Stephens stated, "Every year I take my family back to where I camped with my parents and siblings while growing up. This spectacular country is part of my family heritage." Jimmy Gabettas' family legacy was also emphasized when he said, "My Dad and I have fished the upper Blackfoot and Salt Rivers all of our lives. My Grandfather summered his sheep herds up there and we still return many days each year with nieces and nephews to hunt and fish." The lands are also important to Illinois resident Ron Dyslin who visits the region every year to "fish for the elusive cutthroat trout. The area is so wonderful that I intend to relocate to the valley as soon as I retire." Many others come to these mountains for similar reasons. Malissa Stanley and her family "came to eastern

[1] February 23, 1998 letter from Supervisor Reese to State BLM Director Martha Hahn.

Idaho to live and work near so many wonderful outdoor opportunities. We love to hike and camp."

This place and the values it sustains are threatened by existing open-pit phosphate mining and, in particular, by the proposal of the J.R. Simplot Co. to expand its current operations at the Smoky Canyon Mine. As we detailed in our comments on the draft environmental impact statement (DEIS) on this proposal, existing mines, including the Smoky Mine, are polluting the ground and surface waters of this area with selenium, a toxic contaminant of great concern.[2] As the result, as the U.S. Forest Service's own renowned selenium expert, A. Dennis Lemly, Ph.D, has pointed out, "[t]his ecosystem is a tinderbox…."[3] The Smoky Canyon Mine is already a Superfund site because of selenium contamination and, although cleanup of the existing and ongoing problem there has barely begun, the U.S. Forest Service and the Bureau of Land Management (BLM) appear untroubled by the proposed expansion. As we detail below, there are numerous compelling reasons why the expansion should not be approved, including the fact that the final environmental impact statement (FEIS) does not comply with applicable legal requirements and seriously underestimates the likely consequences if it were to go forward.

A. Experts

To assist us in our review, we have called upon a number of nationally known experts and other authorities, as we did in the case of the DEIS. These individuals include:

- Carolyn Alkire, Ph.D., Environmental Economics and Policy Consultant and Adjunct Professor of Economics, Palomar College, San Marcos, CA.[4]
- Rebecca Carter, Ph.D., is Research Manager for the Socioeconomics Program at the Sonoran Institute, Tucson, AZ. The Sonoran Institute is a West-wide, non-profit conservation organization that assists communities, organizations, and agencies in understanding changing social, economic, political, and climatic conditions and the role that conservation can play in community development and sound land use planning.[5]
- Steven Hamilton, Ph.D., a nationally-known expert on aquatic toxicology who retired from the U.S. Geological Service in January 2004, after 29 years of service with that agency and previously with the U.S. Fish and Wildlife Service. During his career, Dr. Hamilton published extensively on selenium contamination as his CV reveals.[6]
- Edgar A. Imhoff retired from the federal government after a distinguished career that included service in multiple agencies, including the USGS, where as stated above he managed the San Joaquin Valley Drainage Program, the site of major problems with selenium toxicity involving the Kesterson National Wildlife Refuge.[7]

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[2] See GYC et al Comments on the Draft Environmental Impact Statement on Smoky Canyon Mine Panels F and G dated March 20, 2006, pp. 5-8 (hereinafter "GYC et al. DEIS Comments").
[3] Ibid. pg. 3.
[4] Dr. Alkire's CV and the FEIS review which she co-wrote are included in Appendix A.
[5] Dr. Carter's CV and the FEIS review on which she was the lead author with Dr. Alkire are included in Appendix A.
[6] Dr. Hamilton's review of the FEIS is included in Appendix B.
[7] Mr. Imhoff's review of the FEIS is included in Appendix C.

- Tom Myers, Ph.D., is a researcher and consultant in hydrogeology and water resources whose specialties include groundwater modeling, hydrogeology and environmental analysis.[8]
- Patrick C. Trotter, Ph.D., is an expert on cutthroat trout.[9]
- Glenn C. Miller, Ph.D., is a consulting chemist and an expert, inter alia, in remediation of mine waste contamination and the fate and transport of organic compounds in soils and the atmosphere.[10]

These individuals have carefully reviewed the FEIS within their respective areas of expertise and prepared written reviews detailing their concerns, which are included in appendices to these comments, along with other relevant materials. While we summarize and reference their individual concerns in our comments below, we ask and expect, as we did in the case of the DEIS, that their reviews will be read, considered and individually responded to by the agencies.

B. The Legal Framework

Our comments on the DEIS for this proposed project included a detailed discussion of the statutory obligations the agencies are required to meet in carrying out their National Environmental Policy Act (NEPA) review.[11] By this reference, we incorporate that discussion and, in what follows, we summarize it.

As we pointed out in our comments on the DEIS, NEPA is an action-forcing statute. Its sweeping commitment is to “prevent or eliminate damage to the environment and biosphere by focusing government and public attention on the environmental effects of proposed agency action.”[12] Achieving this goal requires that federal agencies and the public are fully aware of the present and future likely environmental impacts of their proposed actions.[13]

To meet NEPA’s full disclosure purpose, agencies must take ‘a hard look’ at the potential environmental consequences of their actions.[14] Taking the requisite hard look at the proposed expansion of the Smoky Canyon Mine requires that the Forest Service and the BLM must provide:

- A thorough and accurate discussion of bioaccumulation, the major environmental concern in connection with this proposal.
- A thorough and detailed assessment of the impacts of the proposed action on the surface and ground waters of the area, and in particular the impacts that expanded

[8] The first of Dr. Myers’ two reports on this FEIS is included in Appendix D. His other report is included in Appendix E.
[9] Dr. Trotter’s FEIS review is included in Appendix G.
[10] Dr. Miller’s review and CV are included in Appendix U.
[11] See GYC et al. DEIS Comments.
[12] Marsh v. Oregon Natural Resources Council, 490 U.S. 360, 371 (1989).
[13] See Robertson v. Methow Valley Citizens Council, 490 U.S. 332, 350 (1989).
[14] Oregon Natural Resource Council v. Lowe, 109 F.2d 714, 717 (9th Cir. 1998).

mining will have on current levels of selenium in area streams, including streams that are already impaired because of elevated selenium concentrations.

- An accurate discussion of the CERCLA actions and activities that have taken place, or are planned, such as the remedial investigation/feasibility study.
- An accurate and comprehensive analysis of the real economic choices posed by this proposed expansion and a full assessment of the economic benefits and costs of expansion, together with the benefits that could result from not expanding the mine.

In preparing the FEIS, moreover, as we also noted in our DEIS comments, the agencies must insure not only that the information that they include is accurate, but also the "professional integrity, including scientific integrity, of the discussions and analyses" contained in the FEIS.[15] Information obtained from the applicant must be "independently evaluate[d]" to verify "its accuracy."

Last, but by no means least, in addition to preparing an FEIS that complies with NEPA's procedural requirements, the agencies are responsible for demonstrating in that FEIS, that they are complying with all applicable laws, including in this particular case, state and federal water laws like the Clean Water Act and Public Water Reserve No. 107, the Resource Conservation and Recovery Act (RCRA), and the National Forest Management Act.[16]

All of these statutes were discussed in our DEIS comments save RCRA. In the Smoky Canyon FEIS, the Forest Service must demonstrate that it will comply with RCRA's solid waste disposal requirements[17] and implementing regulations.[18] In general, with regard to waste rock dumps generated by the mine, the Forest Service must protect surface and groundwater from pollution generated by such disposal. More specifically, the Service must ensure that these dumps do not discharge pollutants and dredge or fill material that violate the CWA, and that they do not cause non-point pollution of water that violates an approved state- or area-wide water quality management plan.[19] In addition, the mine is prohibited from contaminating an underground drinking water source beyond the solid waste boundary of the facility.[20]

As we demonstrate below, the FEIS does not satisfy these applicable legal requirements. Indeed, the Forest Service's own National Ground Water Program Leader concluded that, as the result of the agencies' and Simplot's determination to comply with self-imposed deadlines for completing the FEIS, without regard to its quality or NEPA's requirements, "both the agencies and public are left with a limited understanding" of the most critical part of the proposal, "the cover system, its critical design features, and the key expected stressors"[21] –

[15] 40 CFR §§ 1502.22, 1502.24.
[16] See ibid. § 1502.2(d).
[17] These requirements are set forth at 42 U.S.C. § 6921 et seq,
[18] These regulations are found at 40 C.F.R. Part 257.
[19] See 40 C.F.R. § 257.3-3.
[20] See ibid. § 257.3-4.
[21] January 26, 2007 "Memorandum To: Scott Gerwe – Smoky Canyon Mine Expansion Project Lead, Caribou-Targhee NF From: Christopher Carlson – National Ground Water Program Leader, Washington Office Subject: Assessment of the Cover System for the Proposed Simplot Smoky Canyon Mine Expansion, Panels F & G, Caribou-Targhee National Forest," pg. 2. This document, referred to hereinafter as "Carlson Memo," is included in these comments in Appendix H, together with a cover memorandum from Janine Clayton, Acting Director of

confirming conclusions reached independently by our experts, as discussed below. In short, rather than take the 'hard look' required by NEPA, the agencies have knowingly released an FEIS that fails to disclose fully and with "scientific integrity"[22] the likely environmental consequences of the proposed expansion.

II. Executive Summary

Phosphate mining has been and is a major source of water pollution in southeast Idaho. As the FEIS acknowledges, there are "a number of sites in Southeastern Idaho that have been impacted by selenium released from phosphate mines."[23] The selenium contamination that has already resulted from mining at the Smoky Canyon Mine is significant,[24] but efforts to date have been unsuccessful in remediating the existing problem. In fact as we detail in these comments, Simplot continues to throw up roadblocks to any real cleanup effort, and the Forest Service continues to acquiesce to the mining company. The proposed action addressed in the FEIS is the expansion of Simplot's existing mining activities at the Smoky Canyon into two new panels, F and G. The document acknowledges the selenium problem and in particular, its significance for water quality and purports to analyze the environmental impacts of a variety of expansion options, including a wholly new Agency Preferred Alternative, Alternative D. It concludes that the Alternative D will not cause selenium concentrations that would exceed either surface or groundwater standards at specified points.

The authors of these comments and our experts have carefully reviewed the FEIS and numerous relevant documents and have reached the following major conclusions about the proposed mine expansion and the quality of the FEIS itself.

- The Agency Preferred Alternative considered in the FEIS is unacceptable because it will result in increased selenium contamination of already contaminated ground and surface waters in the area.
- The amount of selenium contamination in ground and surface waters that will result should the proposed expansion be permitted to go forward has been seriously underestimated by the FEIS due to flaws in groundwater modeling, the reliance on the new and untested "store and release" cover design and the hoped for cleanup of the existing Smoky Canyon Mine Superfund site.
- Not only has the current impact of selenium on aquatic resources been "wished away" in the FEIS with the addition of Appendix 3C, but also the potential cumulative impact

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Minerals and Geology Management, Forest Service, dated January 31, 2007, transmitting it to Larry Timchak, Supervisor, Caribou-Targhee National Forest. Both documents were received by Lisa Evans, Earthjustice, on December 13, 2007, as the result of a Freedom of Information Act (FOIA) request she had filed.. Appendix H also includes another memorandum dated October 19, 2006 from Dr. Carlson to Scott Gerwe, Subject: "Tasks to Complete Simplot Cover Design," which is referred to hereinafter as "Carlson Memo 2." Lastly, Appendix H includes a July 6, 2007 memorandum from three agency staffers that purports to respond to Dr. Carlson's criticisms of the new cover design. These documents too were received on December 13, 2007 as were a number of other agency documents that are referenced in these comments and included in different appendices.

[22] 40 CFR §§ 1502.16, 1502.24.

[23] FEIS, pp. 3-16 and 3-51.

[24] Newfields, 2005. Final: Site Investigation Report, Smoky Canyon Mine, Caribou County, Idaho. Prepared for J.R. Simplot Co. Boulder CO, July 2005.

of the added selenium that will result from expanded mining has been seriously underestimated, due in large part to the document's continued failure to take into account the bioaccumulative nature of selenium.

- The impacts of connected actions at the mine have been erroneously excluded from analysis.
- Unjustifiable assumptions about the efficacy of reclamation, Best Management Practices and other corrective actions as well as the resulting impacts have been made repeatedly.
- Other resources of the area, including especially fish, are already experiencing selenium-related stress, which is certain to increase if the expansion is approved. The severe impacts that the mine expansion will have on Yellowstone cutthroat trout have not been appropriately assessed.
- Conclusions cannot be drawn about other species of wildlife because the Forest Service has not selected appropriate management indicator species.
- The real social and economic tradeoffs of approving the proposed expansion have not been acknowledged or adequately assessed.
- The FEIS suffers from significant flaws and is so inadequate as to preclude meaningful decision-making. In addition, the Agencies have attempted to make up for these flaws by shoehorning thousands of pages of new information into the FEIS. The FEIS should therefore be withdrawn and the Agencies should develop and issue a supplemental EIS.[25]

In the remainder of these comments, we detail the major flaws in both the Agency Preferred Alternative and the FEIS. Our comments are organized as follows:

In Section III, we detail the agencies' seeming inability to protect public resources and the public from the impacts of phosphate mining and its associated selenium contamination over a period of decades. We also document the equally abysmal track record of the agencies and the mining industry, including Simplot, for predicting the impacts of new mining operations. We then document the poor track record the agencies and companies have when it comes to cleaning up contaminated mine sites or even to develop sound mining and reclamation methods that will not result in future Superfund Sites. Lastly, we include a discussion of the agencies' refusal to follow the Lemly protocol in this section.

In Section IV, we discuss the flawed assumptions contained in the FEIS' treatment of water quality impacts, including its reliance on the unproven, new cover "design," to prevent future selenium contamination of ground and surface waters, and the flawed groundwater model that is in large part responsible for the agencies' dismissal of concerns about future selenium contamination. We then provide a discussion of the FEIS's overly optimistic reliance and misplaced hope that the CERCLA clean up actions at the Smoky Canyon Mine will abate current selenium contamination in the short time frame envisioned. We also document the need for an NPDES permit for the proposed mine expansion, given the violations of State water quality standards that will result. Finally, we address the proposal's impacts to springs and seeps.

[25] 40 CFR § 1502.9(a) and (c).

In Section V, we discuss impacts to aquatic resources, in particular, impacts to Yellowstone cutthroat trout, including the risk of extinction in the local and regional areas. This section also includes an extensive critique of Appendix 3C.

In Section VI, we discuss the myriad violations of NEPA that the agencies have committed, including the need for a supplemental EIS; the failure to insure the accuracy and professional integrity of information, including the dependence on flawed documents, inconsistencies in the FEIS, the failure to disclose all relevant information; problems with the cumulative effects analysis and connected actions; and incomplete and/or unavailable information.

Section VII of these comments addresses specific deficiencies with issues related to Forest Service activities on Forest Service managed lands, including impacts to roadless areas, problems with the proposed use of Special Use Permits, and the failure by the Caribou-Targhee National Forest to select and monitor appropriately selected management indicator species.

Section VIII includes a thorough discussion and analysis of numerous CERCLA/RCRA deficiencies in the FEIS.

Section IX addresses deficiencies in the FEIS' treatment of human health deficiencies and Section X discusses deficiencies in the treatment of economics

In Section XI of our comments, we discuss operational issues, specifically monitoring and bonding.

Finally, the last section of our comments, Section XII, provides our conclusions and recommendations.

Much is at stake with the proposed action: the long-term health of the region's renowned resources for its present and future generations, its economic health and the future of its communities. The FEIS threatens to set the area on the path toward becoming another Kesterson, another national tragedy caused by decision-makers' failure or unwillingness to understand and appreciate the risks of selenium. The organizations and individuals submitting these comments urge the agencies to step off that path and withdraw the FEIS. With so much at stake, both the public and decision-makers deserve and need what NEPA demands – a full accounting of the potential impacts of the proposed action and, in particular, a full understanding of the impacts of releasing still more selenium into the environment – before it is too late.

III. History of Failure

In 1996, local newspapers in southeast Idaho reported that six horses in lower Dry Valley had to be euthanized because they had become so sick from selenium poisoning.[26] As is well

[26] Montgomery Watson (MW). February 1998. Fall 1997 interim surface water survey report, Southeast Idaho Phosphate Resource Area Selenium Project. Prepared for the Idaho Mining Association Selenium Committee.

known now, the selenium that poisoned the horses originated at the South Maybe Canyon Mine. This public revelation put phosphate mining and selenium contamination of the environment on the radar screen of many people who live in southeast Idaho. The mining companies, their industry umbrella group – the Idaho Mining Association – and a number of the state and federal agencies circled their wagons to defuse the situation. However, over the next five years there were more reported cases of livestock deaths caused by acute selenium toxicity. The selenium that caused the deaths was released during phosphate mining operations. As reported by Hill,

> [a]cute toxicity, which involves the rapid onset of a severe effect following exposure to a relatively high concentration of toxicant over a short period time, occurred in three herds of sheep that died within hours or days of consuming high concentrations of selenium. In September 1999, approximately 60 sheep died after consuming selenium-contaminated forage or spring water near the Stauffer mine site in Wooley Valley (Caribou County Sun, November 11, 1999; Idaho State Journal, November 12, 1999). In June 2001, approximately 160 sheep died after drinking spring water located down-gradient of the Conda mine site (Idaho State Journal, June 6, 2001). And in May 2003, 327 ewes and lambs died after grazing at the reclaimed overburden dump site at the Conda mine site (Caribou County Sun, June 19, 2003).[27]

These public reports of livestock deaths resulted in a number of actions by the mining industry and state and federal regulatory and land management agencies. First and foremost, there was a concerted effort to persuade the public that the selenium contamination was totally unexpected and unknown before the 1996 deaths of the horses in Dry Valley. Another outcome was that the permitting agencies began requiring phosphate mining companies to develop new mining and reclamation practices in an attempt to halt the release of selenium into the environment and thereby protect human health, water, soils, and wildlife of southeast Idaho. Another notable outcome of the public revelation of the livestock deaths has been the sporadic, and as yet incomplete, attempt on the part of regulatory agencies to enter into Administrative Orders on Consent under CERCLA with the individual phosphate mining companies to investigate and ultimately remediate seventeen phosphate mine Superfund sites.

In the following sections we discuss these three issues, and how they relate to the proposed Smoky Canyon Mine expansion.

A. Failure to Inform the Public

A recent report prepared by retired federal hydrologist and environmental clean up expert, Edgar Imhoff, documents that the federal land management agencies responsible for oversight of phosphate mining in southeast Idaho knew for decades of the toxic selenium contamination caused by that mining.[28] Nonetheless, the phosphate mining industry together with federal

[27] Sheryl Hill. An Analysis of Selenium Concentrations in Water and Biological Tissue Samples Collected in the Upper Blackfoot River and Salt River Watersheds from 1997 to 2003. June 2005.

[28] Edgar Imhoff. Environmental Contamination from Selenium in Southeast Idaho: Who Knew What, and When Did They Know It. September 2007, included in Appendix I of these comments.

land managers claimed publicly that the harmful effects of elevated selenium concentrations were not known until after the 1996 reporting of horses being euthanized after becoming poisoned by selenium.

Imhoff reviewed thousands of pages of documents obtained through a Freedom of Information Act request from federal agencies earlier this year. His report shows that, based upon these and other published documents, mining companies and agencies clearly knew for decades of the potential harm from selenium contamination. Imhoff's report documents the history of selenium research showing that reasonable knowledge of harm from selenium dates back to the late 1970s. "By the 1970s information on the potential toxicity of selenium was circulating generally throughout fish and wildlife agencies in the Western US." The report also states, "Beginning in the 1980s, there was considerable scientific information available…. Indeed, there is evidence that, by the late 1980s, the phosphate industry was fully aware of the potential for selenium contamination…."[29]

The consequences of keeping this information from the public, as documented in Imhoff's report, are that during a two-decade period additional mines were permitted and mined, all of which are now Superfund sites. There are currently 31 phosphate mines in southeast Idaho, 17 of which are designated as EPA Superfund sites and none of which have been cleaned up. By definition,[30] each of these sites is releasing or threatening to release "hazardous substances that may endanger public health or the environment."

Imhoff's report comes to light as industry and federal managers are once again seeking to permit additional new mining with this FEIS. The agencies are set to approve the new mine panels despite repeated environmental violations involving selenium, rising selenium concentrations in streams and aquifers, and additional science showing the potential harm of such contamination. Even in this FEIS, after Imhoff's report documented that the agencies knew of selenium contamination decades before they admitted it, the agencies are still claiming they didn't know there was a problem before 1997.

> The selenium problem in Southeastern Idaho was not recognized by the Agencies and the industry until the late 1990's…."[31]
>
> Prior to 1997, selenium was not recognized by the mining industry or regulatory agencies in Southeastern Idaho as the primary contaminant released to the environment from phosphate overburden.[32]

However, that claim is belied elsewhere in the FEIS: "Beginning in 1987, for lower Pole Canyon Creek below the overburden fill, every sample collected at that site has contained selenium concentrations greater than 0.005 mg/l."[33] (emphasis added.)

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[29] Ibid.
[30] http://www.epa.gov/superfund/policy/cercla.htm. Last visited December 17, 2007.
[31] FEIS, pg. 7-84.
[32] Ibid. pg. 5-8
[33] Ibid. pg. 5-34.

The agencies' willingness to permit this expansion based on a deeply flawed groundwater model, an experimental store-and-release cover design for selenium-laced overburden that even the Forest Service's own expert contends will likely fail, and a hope that, sometime in the future, cleanup at the severely contaminated portion of the Smoky Canyon Mine will be successful continues an approach that has failed in the recent past and will ultimately lead to more contamination and an even larger Superfund site at Smoky Canyon.

B. Failed Mine and Reclamation Plans

As examples of what can be expected should the Smoky Canyon Mine Panels F and G expansion be permitted, one needs only to look at the three mining operations most recently permitted in the region. The mine and reclamation plans for these mines/mine expansions were all permitted since 2000, years after even the agencies acknowledged that selenium and metal contamination were the most significant issues in permitting new phosphate mines in this region. These plans have all failed to prevent selenium and/or other contaminates from being released into the environment, releases that vastly exceed the overly optimistic forecasts made by the mining companies and permitting agencies.

1. Dry Valley Mine

Agrium (Nu West Industries)
Permitted August 2000 by FMC Corporation

This expansion was permitted based in large part on new cap designs. According to the Dry Valley South Extension FEIS Mitigation and Monitoring Plan, three "new" Growth Medium Cap (GMC) designs were developed to

> separate vegetation from underlying overburden materials and to control infiltration of surface water through the GMC into the overburden materials that it covers. A GMC that accomplishes these two general objectives will limit root penetration into and potential uptake by plants of selenium and trace metals present in overburden materials and limit leaching of selenium and trace metals by minimizing infiltration into the overburden and subsequent transport to surface and groundwater systems.[34]

And,

> [a] Growth Medium Cap is intended to inhibit, interrupt, or eliminate pathways of trace metals from underlying overburden materials and to control infiltration of surface water through the Growth Medium Cap into overburden material. Attaining these two objectives would limit root penetration into overburden and potential uptake of selenium and trace metals by plants, and limit leaching of selenium and trace metals from overburden by minimizing infiltration and subsequent transport to groundwater and surface water systems.[35]

And,

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[34] Mitigation and Monitoring Plan (Dry Valley Mine) South Extension Project, pg. 10 (June 2000).
[35] FEIS, Dry Valley Mine – South Extension Project, pg. 2-49 (June 2000).

> [t]he predictive models used in the EIS indicate that modifying planned mining operations in this manner would reduce selenium releases from overburden dumps to surface water, shallow ground water and reclamation vegetation.[36]

Groundwater monitoring and modeling for Panels C and D (South Extension) reveal that cadmium – a primary standard, and aluminum, manganese, iron, and sulfate – secondary standards, would exceed maximum contaminant levels for groundwater in both the short and long term.[37] It was these exceedances that resulted in the Idaho Mining Association's attempt, in 2007, to expand the exemption for groundwater pollution caused by mining operation in Idaho.

2. South Rasmussen Ridge Mine

Monsanto (P-4 Production)
Permitted in January 2001

A similar pattern of agency optimism is seen in the environmental assessment and Record of Decision for Monsanto's most recently permitted mine.

> The South Rasmussen Mine site has no perennial streams and limited intermittent drainages that might serve as conduits to selenium transport. It is anticipated that any selenium would remain onsite. The final configuration of the pit authorized by this decision record and FONSI on Federal lease would be empty. It is anticipated that this would not allow selenium or other contaminants to migrate from the lease.[38]

And,

> Solutia [Monsanto] has committed to implement operational practices and best management practices to minimize and control selenium generation.[39]

And,

> [i]t is my decision that these recommendations and Best Management Practices from the interagency/industry task force be applied to the SRM & RP as outlined in condition of approval #5. This will allow application of effective mitigation measures for selenium at the South Rasmussen Mine as they are developed in this dynamic, scientific process.[40]

Since Monsanto's South Rasmussen Ridge Mine was permitted, there have been at least two Notices of Violation (NOVs) issued by the EPA, one in January 2005, and one in February

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[36] Record of Decision FMC Dry Valley Mine-South Extension Project, pg. 5 (July 26, 2000).
[37] Bureau of Land Management. Letter to Dry Valley Mine Manager, NuWest Industries, Federal Phosphate Lease I-014184. July 19, 2006.
[38] Finding of No Significant Impact/Decision Record, Solutia South Rasmussen Ridge Mine and Reclamation Plan, pp. 4-5.
[39] Ibid. pg. 5.
[40] Ibid.

2006.[41] The 2005 NOV indicates that selenium exceedances into West Fork Sheep Creek, a perennial stream, were noted first in April 2002, approximately 16 months after the permitting agencies optimistically predicted there would be no problems with selenium contamination because of the new mine and reclamation plans. The exceedances of selenium were then repeated and reported every year after 2002 until 2005. In May of 2006, Idaho Department of Environmental Quality (DEQ) water quality data from Sheep Creek indicated that for the first time selenium levels exceeded state standards (0.009 mg/L = 9µg/L). Sheep Creek is an important Yellowstone cutthroat trout stream in the Blackfoot River basin. In 2007, EPA again issued a Notice of Violation to the South Rasmussen Mine after a May 8, 2007 NPDES compliance inspection once uncovered unremediated seeps discharging to the West Fork of Sheep Creek.[42] EPA noted that the seeps contained levels of selenium up to 150 times the Idaho water quality standard.[43]

3. Smoky Canyon Mine

J. R. Simplot Company
Panels B and C Expansion permitted in June 2002[44]

The agencies and the J.R. Simplot Company exuded the same optimism in the final SEIS for the Panels B and C expansion of the Smoky Canyon Mine. The SEIS notes,

> [s]elective handling of mine overburden would be practiced during the proposed operations. Waste overburden shales known to contain elevated concentrations of selenium (seleniferous) would be handled separately from other overburden. Low selenium content (non-seleniferous) chert and limestone overburden (hereafter referred to as "chert") would also be handled separately. This chert overburden would be spread over the seleniferous overburden shales at a thickness of approximately eight feet at the external overburden disposal facility and the pit backfill areas. This thickness of chert cover is intended to prevent the underlying seleniferous overburden shales from erosion and prevent root penetration.[45]

And,

> [r]oughly three times as much clean runoff water would recharge in these areas as would percolate through the seleniferous overburden so the potential groundwater impacts from the seleniferous overburden seepage would be reduced by the combined effects of raising local water tables under the runoff

[41] This NOV was for violations of the NPDES Multi-sector General Permit.
[42] US EPA, Notice of Violation and Request for Information to P4 Production's Rasmussen Mine, September 17, 2007, pertaining to May 8, 2007 NPDES Compliance Sampling Inspection, MSGP Tracking No. IDR05A351. This NOV is included in these comments in Appendix V.
[43] Ibid. pg. 2.
[44] Idaho State Journal, Legal Notices, Notice of ROD, June 1, 2002.
[45] Smoky Canyon Mine Panel B and C FEIS, pp. 2-18 & 2-19 (April 2002).

> recharge areas and by mixing the seepage through the seleniferous overburden with three times as much clean water.[46]

And,

> [s]elective handling of mine overburden would be practiced during the proposed operations. Waste overburden shales known to contain elevated concentrations of selenium (seleniferous) would be handled separately from other overburden. Low selenium content (non-seleniferous) chert and limestone overburden (hereafter referred to as "chert") would also be handled separately. This chert overburden would be spread over the seleniferous overburden at a thickness of approximately eight feet at the external overburden disposal facility and the pit backfill areas. This thickness of chert cover is intended to protect the underlying seleniferous overburden shales from erosion and prevent root penetration. One to three feet of topsoil would be spread over chert cover to complete the cap.
>
> Although the chert cap is designed to cover all areas of seleniferous overburden and isolate it from the surface environment, it would be permeable to infiltration of meteoric water from rain and snowmelt. However, the grading of the cap encourages runoff rather than infiltration over this area with eventual collection of non-selenium bearing runoff water at the chert margins of both the external and internal overburden fills. At these margins, the collected runoff would be allowed to percolate into chert fill "Runoff Recharge Areas" (see FSEIS figure 2.2-7) and into the permeable bedrock foundation, serving to recharge the local groundwater aquifer with large amounts of fresh water, thus reducing offsite discharge of runoff water and the selenium concentrations in groundwater contributed from percolation through seleniferous overburden.[47]

And,

> [t]he Proposed Action (with mitigation) would result in the shortest time period of disturbance of surface natural resources of the three action alternatives. It would also expose seleniferous overburden to surface weathering and erosion for the shortest amount of time.[48]

And,

> [a]fter considering the conservative nature of the modeling used to derive these predictions however, the BLM has selected the Proposed Action (with mitigation). The predicted effects on groundwater quality are based on conservative modeling and may be less than predicted; are localized within the mine area; and are not predicted to impact surface resources or human health.

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[46] Ibid. pg. 2-23.
[47] Smoky Canyon Mine Panel B and C Record of Decision, pp. 8-9.
[48] Ibid. pg. 13.

> Substantial mitigation measures have been added to the Panel B & C mine plan since its original submittal to BLM in 1999 and evaluation in the Draft SEIS. The overburden (waste rock) management elements contained in the Selected Alternative (see FSEIS figure 2.2-6 and section 2.9.2) are designed to eliminate the potential for formation of seleniferous overburden seeps from the external overburden disposal site, which was the main reasons for considering Alternatives A and B. Foundation permeability control, selective placement of overburden, surface runoff management, and collection and subsurface recharge of surface runoff will provide multiple layers of protection to reduce the potential for development of seleniferous seeps along the margin of the external overburden fill. (emphasis in original)
>
> Design of the overburden disposal facilities is expected to reduce the area of significant groundwater impacts from seepage through seleniferous overburden to the immediate vicinity of the mine disturbance. Downgradient groundwater quality is expected to comply with State protection standards. Simplot has entered into a legally binding Consent Order with the State of Idaho to ensure that groundwater quality is not impacted above allowable standards.
>
> The selective handling of overburden would result in a minimum 8-foot thick chert cap over all areas of seleniferous overburden to prevent its long-term release to the environment through vegetative uptake, direct contact, or erosion. All disturbed areas would also be covered with 1 to 3 feet of native soil for re-establishment of permanent vegetative cover. These and other management practices are expected to reduce to acceptable levels impacts to surface resources including soils, surface water, vegetation, wildlife, livestock grazing, visual resources, and recreational uses of the public land.[49]

However, instead of protecting groundwater as so optimistically predicted by the agencies and Simplot, this "state of the art" mitigation plan failed. Just three years after the expansion was approved and only two years after mining began, problems showed up. According to a report by Newfields, Simplot's consultant,

> [a]t the A Panel, a rapid increase in selenium concentration was observed at the Culinary Well following a period of high precipitation, runoff, and direct recharge to the Wells Formation from constructed runoff recharge areas in the un-reclaimed A Panel.[50]

And,

> [t]he potential for selenium transport from local sources is further supported by

[49] Ibid. pg. 21.
[50] Newfields. Technical Memorandum Water Quality Monitoring Data Report Fall 2006 Smoky Canyon Mine - Area A, pg. 5 (January 29, 2007).

> recent observations at A Panel and the mine's Culinary Well during and after several months of high precipitation in early 2005.[51]

And,

> [t]he selenium concentration in groundwater from the Culinary Well increased during the summer of 2005 to a concentration above the location specific background limit of 0.028 mg/L. Simplot notified IDEQ of this condition in accordance with an IDEQ Consent Order (dated April 2003) that specifies requirements for compliance with the Idaho Groundwater Quality Rule at the Smoky Canyon Mine B Panel and C Panel mining areas.[52]

The January 29, 2007 Newfields report and this FEIS[53] would have readers believe that this was a one-time occurrence. However that is not the case. The March 26, 2007 annual monitoring report for Smoky Canyon Panels B and C reports that selenium concentrations from samples taken at the Culinary Well for all four quarters were above the (alleged[54]) background limit of 0.028 mg/L.[55] In the first quarter, the concentration was 0.0358 mg/L; in the second quarter, it was 0.0431 mg/L; it was 0.0456 in the third quarter; and 0.0354 mg/L in the fourth quarter. As Dr. Tom Myers noted in November of 2007, "[a]s for running water directly into the Wells formation, that's what got them into trouble at the culinary well."[56]

C. Failed Cleanup Promises

When evaluating whether the decision maker and the public can rely on the prediction of timely and successful cleanup at the Smoky Canyon Mine, a rational person must examine what has actually occurred at the Smoky Canyon Mine Superfund Site[57] and at the other phosphate mine CERLCA sites managed by the Forest Service. This section examines numerous southeast Idaho phosphate mine CERCLA sites, including the Smoky Canyon Mine Site, and demonstrates that the Forest Service has been unable to complete successfully any investigation leading to cleanup or any cleanup at the contaminated phosphate mines. The record clearly reveals that the Forest Service has uniformly failed to effectively investigate and remediate these sites, despite the passage of at least a decade since the discovery of contamination at many of them. Certainly the track record of the Forest Service must deter any rational decision maker from relying on simply the *promise* of cleanup.

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[51] Ibid. pg. 6.
[52] Ibid. Attachment 1, pg. 1.
[53] FEIS, pg. 4-47.
[54] Alleged because there are only two water samples from the Culinary well prior to 1996. One is from 1989 and the other from 1994. The 1989 concentration is 0.006 mg/L and the 1994 is 0.005 mg/L, which are both well below the supposed background level of 0.028mg/L. It wasn't until 1996 and later that selenium in water from the Culinary well was found to be elevated - that is twelve years after mining commenced at Panel A. Newfields, Background Monitoring Data for Culinary Well (1988-2001), pg. 243.
[55] J.R. Simplot Company Smoky Canyon Mine, Consent Order: Panels B&C Monitoring Activities & Results CY-2006.
[56] Tom Myers, personal communication, November 10, 2007.
[57] Figures 1a, 1b, and 1c in Appendix F are a Google Earth visualization of the Smoky Canyon Mine divided into three equal parts.

1. Smoky Canyon Mine

a. Operation of Smoky Canyon Mine in Violation of Federal Law

Before commenting specifically on the Forest Service's failure to move the Smoky Canyon Superfund Site toward timely cleanup, it is essential to place the present CERCLA action in context. For decades, the Smoky Canyon Mine has been operating as an illegal open dump in violation of federal law under RCRA[58] and has been discharging pollutants into surface water in violation of the federal Clean Water Act (CWA).[59] Enforcement of federal law has been stalled since 2000 as environmental groups and citizens injured by the contamination wait for abatement of the releases and initiation of clean up under CERCLA. Thus the Forest Service's unjustifiable delay under CERCLA to require investigation and cleanup adds insult to injury as the existing violations continue to worsen conditions at the Smoky Canyon Mine Superfund Site.

The 2003 Smoky Canyon Administrative Order on Consent (AOC) produced a glimmer of hope that the mine would come into compliance with applicable law, stop illegal dumping, and, <u>within a reasonable time</u>, begin clean up of the extensive damage at the Site. The Forest Service, however, allowed the Engineering Evaluation/Cost Analysis (EE/CA) investigation to drag on for over three and a half years, and the end result could not have been more disappointing. Following the release of the final EE/CA in May 2006, the Forest Service announced that it was addressing just <u>one</u> of the five areas evaluated in the EE/CA.[60] It was clear to numerous experts that this limited action would fail to stop releases of selenium from the Site and would fail to stop highly contaminated groundwater from further contaminating groundwater and surface water both onsite and offsite. In the 18 months following the release of the EE/CA, the Forest Service failed both to implement a successful removal action at Pole Canyon, the sole area the Forest Service decided to address, and to attain an agreement with Simplot to investigate the rest of the Site under CERCLA remedial authority, as promised.

b. The Failure of the Pole Canyon Removal Action

In October 2006, the Forest Service issued an Action Memorandum approving the non-time critical removal action at the 26 million cubic yard Pole Canyon Overburden Disposal Area (ODA).[61] Construction began in August and the pipeline was complete by February 2007.[62]

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[58] A criterion for classification of open dumps and the practice of open dumping is the facility's adverse impact on groundwater. In section VIII of these comments below, we discuss this issue in detail.
[59] Citizen groups have brought federal law violations to the attention of the Forest Service, EPA, Idaho Department of Environmental Quality (IDEQ) and Simplot, without recourse due to the ongoing CERLA action as established by the AOC/Consent Order (CO). In fact, efforts to enforce the CWA were initiated by GYC and ICL in 2003, but postponed pending resolution of the AOC/CO.
[60] Letter from Jeffrey L. Jones, Forest Service to Alan Prouty, J.R. Simplot Company dated June 7, 2006, included here in Appendix J.
[61] USDA Forest Service, Action Memorandum, Request for Approval of Non-Time- Critical Removal Action at Pole Canyon Overburden Disposal Area, CERCLIS ID No. IDN001002245-02, October 2, 2006. Figure 26 in Appendix F shows the Pole Canyon fill being constructed circa 1986.

Immediately, however, engineers discovered leaks in the system. By April 2007, testing indicated that approximately 6800 feet of the 10,400-foot pipeline leaked.[63] Consequently spring precipitation and runoff through the Pole Canyon ODA delivered another substantial load of selenium to Hoopes Spring and Sage Creek. Throughout 2007, highly contaminated water continued to discharge from the toe of the ODA at levels 300 times water quality standards and 1.5 times the regulatory level for hazardous waste.[64]

In the summer of 2007, the leaking pipeline was removed and replaced. The pipeline currently in place is thus no more than three months old and untested. No one can be assured that this pipeline will not fail during periods of high runoff and precipitation as the original pipeline did. As evidence of the unpredictability of the process, the Forest Service approved an eleventh hour design modification for the pipeline on August 20, 2007 and another design modification for the infiltration basin on October 12, 2007 because "excavation revealed that the distribution of geologic formations underlying the basis is slightly different than envisioned."[65] No one can say for certain how the pipeline, infiltration basin and related structures will operate in the spring of 2008.

The FEIS, however, fails entirely to mention the catastrophic failure of the first removal action at Pole Canyon. This misleading treatment, which entirely avoids the admission of past problems, is inexcusable given that the agencies had full knowledge of all details of this failure. Furthermore this failure is directly relevant to the agencies' predictions of success for the proposed expansion and is discussed below.

c. Failure of the Forest Service to Enter into an Agreement for an RI/FS

As discussed elsewhere in these comments, the Forest Service has failed, despite the passage of 18 months, to enter into an enforceable agreement with Simplot to complete a Remedial Investigation/Feasibility Study (RI/FS). As explained in Section IV, there is no reason to believe an agreement to complete the RI/FS will be signed anytime soon. One needs only to look at the other CERCLA sites under Forest Service control in the region to see a similar pattern of failure and unjustifiable delay in obtaining these agreements.

2. South Maybe Canyon

The conspicuous lack of timely progress in both investigation and cleanup at the South Maybe Canyon Mine Superfund Site is typical of the CERCLA sites managed by the Forest Service in southeastern Idaho. In 1998, after high levels of selenium in Maybe Creek had resulted in the death of several horses, the Forest Service entered into its first CERCLA AOC with Nu-West Industries for investigation of the release of hazardous substances from the mine. The 1998

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[62] USDA Forest Service, Phosphate Newsletter, August 2007.
[63] Ibid.
[64] FEIS, Appendix 2A, pg. 2.
[65] Hansen, Brian, Newfields, Inc. Letter to Mary Kauffmann, USDA Forest Service, Design Modification Nos. 2 and 3, Removal Action Implementation Work Plan Addendum 1 and Removal Action Design Report. October 18, 2007.

AOC occurred nine years after a USFS 1989-1993 study of Maybe Creek that found extremely high selenium levels in the creek.[66] The 1998 AOC with Nu-West Industries required the completion of a Site Investigation and EE/CA for the South Maybe Canyon Mine. According to the Forest Service, the Site Investigation, which took nearly ten years, was completed in 2007.[67] Nu-West is now required to "present an EE/CA report detailing remedial alternatives."[68] The Forest Service, however, has also indicated that it is currently in negotiations with Nu-West to perform a RI/FS, having determined, after nine years of study that the site demands a more in-depth analysis than can be accomplished in an EE/CA. In any event, removal or remedial actions, indeed even the completion of investigations at the site, are unquestionably many years away.

While the releases of hazardous substances continue unabated from the South Maybe Canyon Superfund Site, one wonders where all the time went. The environmental threat posed by the South Maybe Canyon Superfund Site is similar to the Smoky Canyon Superfund Site. An immense 120-acre cross-valley fill containing 32 million tons of seleniferous rock releases high levels of selenium to groundwater and surface water.[69] According to a 1999 report, levels of selenium in surface water downstream of the South Maybe Canyon cross-valley fill measured 1.5 mg/L (300 times the water quality standard).[70] In the years since that investigation, conditions did not improve. In Nu-West's seventh supplement to its Site Investigation dated 2007, the level of selenium at that same monitoring point during the same month of the year measured 2.23 mg/L (over 440 times the water quality standard).[71] During the nine years of study, the Forest Service failed to require Nu-West to expand the very limited groundwater and surface water sampling at the Site or to characterize the hydrogeology of the site. In sum, the Forest Service has accomplished almost nothing, despite the passage of nearly two decades since the Agency first found significant contamination from the Maybe Canyon waste dump. The Forest Service has provided no public estimate as to when the EE/CA will be submitted or when an agreement to conduct an RI/FS will be in place.

3. North Maybe Canyon

The North Maybe Canyon Superfund Site is following a similar pattern to the Smoky Canyon Mine and South Maybe Canyon Superfund Sites. The Forest Service entered into an AOC with Nu-West in 2004 to complete a Site Investigation and EE/CA. According to the Forest Service, after three years, Nu-West is still gathering data for the Site Investigation.[72] There is no agreement to initiate an RI/FS at the Site, although the Forest Service has admitted that an RI/FS is necessary.

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[66] TRC Mariah Associates, Inc. Maybe Canyon Site Investigation, Caribou National Forest, Caribou County, Idaho, March 1999, pp. 19-20. The Site Investigation consists of an initial 1999 investigation and seven supplemental investigations that annually provided updated monitoring data.
[67] USDA Forest Service, Phosphate Newsletter, May 10, 2007.
[68] Ibid.
[69] TRC Mariah Associates, Inc. Maybe Canyon Site Investigation, Caribou National Forest, Caribou County, Idaho, March 1999, pg. 22.
[70] Ibid.
[71] TRC Environmental Corporation, Seventh Supplement to the Maybe Canyon Site Investigation, Caribou National Forest, Caribou County, Idaho, May 2007, pg. 19.
[72] USDA Forest Service, Phosphate Newsletter, May 2007.

Despite the lack of progress toward the EE/CA, the Forest Service announced, in August 2007, the pending approval of a "removal action" at the North Maybe Canyon East Mill Dump. According to the Forest Service, the ponds located at the toe of North Maybe Canyon's immense cross valley fill are loaded with 12,000 cubic yards of sediment and no longer act as effective traps to protect the water quality of East Mill Creek.[73] The Agency believes that the ponds pose "threats to public health, welfare or the environment" and that the waste dump needs to be stabilized and the ponds' sediment removed.[74] Although the Forest Service has stated that there is a target date of late summer 2008 for initiation of this removal action, past history indicates that it is unlikely to be met.[75] Nu-West has not yet prepared the EE/CA to support this action, and, as stated above, it has not yet completed the Site Investigation.

4. Wooley Valley Mine

At the Wooley Valley Mine Superfund Site, the Forest Service has also made very little progress toward any investigation or cleanup. According to the Forest Service, negotiations have just begun with Rhodia L.L.C. to conduct a RI/FS to address selenium releases from the Wooley Valley Mine Site.[76] Yet a Preliminary Assessment of the Wooley Valley Site was completed seven years ago under CERCLA. Despite the completion of the Preliminary Assessment in 2000, no further investigation was conducted at the Wooley Valley Mine. The Forest Service failed during those seven years to enter into any agreement with Rhodia to conduct a Site Investigation, EE/CA or RI/FS. This inaction contradicts the Preliminary Assessment's explicit recommendation that further investigation be initiated. According to the Forest Service's own description:

> In the Preliminary Assessment (PA), the contractor noted that … the waste production … was estimated as 27.9 million cubic yards of waste material. The contractor noted elevated concentrations of selenium in surface water samples in ponds at the Mine, in seeps from dumps at the Mine, and in Angus Creek and the Blackfoot River. Angus Creek and the Blackfoot River are known to contain Yellowstone Cutthroat trout habitat suitable for spawning. The contractor recommended additional characterization of the potential surface water contamination, as well as additional characterization of groundwater, soil and bioaccumulative effects from the Wooley Valley Mine.[77]

In May 2005, according to the Forest Service, an AOC for an EE/CA was provided to Rhodia, but no agreement was reached in the intervening two years. As noted above, in 2007, the Forest Service decided to require a much more substantial effort from Rhodia in the form of an RI/FS. It is not known when, or if, the Forest Service will attain such an agreement voluntarily from Rhodia. In light of their difficulty securing an agreement for the much less comprehensive, and thus much less costly, EE/CA, the

[73] USDA Forest Service, Phosphate Newsletter, August 2007.
[74] Ibid.
[75] Ibid.
[76] USDA Forest Service, Phosphate Newsletter, August 16, 2007.
[77] USDA Forest Service. Memorandum to Regional Forester, Wooley Valley Mine, Transition from Removal to Remedial Process under CERCLA, February 21, 2007.

outcome of RI/FS negotiations is questionable, at best. The most the Forest Service can offer is a confirmation that negotiations with Rhodia for an RI/FS began in late summer 2007 and an acknowledgement that such a study "could take several years."[78]

5. Champ Mine

At the Champ Mine Superfund Site, the Forest Service similarly has made very little progress toward investigation and cleanup. Despite completion in 2000 of a Preliminary Assessment under CERCLA at the Champ Mine, no further investigation whatsoever has occurred at the site during the last seven years. As with Rhodia, the Forest Service failed during those seven years to enter into any agreement with Nu-West to conduct a Site Investigation, EE/CA or RI/FS. This inaction contradicts the Preliminary Assessment's explicit recommendation that further investigation be initiated. According to the Forest Service's own description:

> In the Preliminary Assessment (PA), the contractor estimated that 24.5 million cubic yards of waste material were produced during mining activities. The contractor also concluded that selenium contamination from the Champ Mine dumps is impacting the surface water quality of Upper Goodheart Creek. Springs forming upper Goodheart Creek flow into Goodheart Creek, which in turn flows into Slug Creek and the Blackfoot River potentially affecting Yellowstone cutthroat trout habitat. Measurements by the Forest Service in the spring of 2006 indicate that the North Champ Mine pit is about 40 feet from Goodheart Creek at its closest point. Each spring the edge of the pit slumps closer to Goodheart Creek. The PA contractor recommended additional characterization of the potential surface water contamination, as well as additional characterization of groundwater, soil and bioaccumulative effects from the Champ Mine.[79]

In May 2007, the Forest Service sent Nu-West a proposed Administrative Settlement Agreement and Order on Consent for an RI/FS at the Champ Mine Site.[80] It is not known when, or if, an agreement will be reached.

6. Mountain Fuel Mine

Once again, at the Mountain Fuel Mine Superfund Site, progress toward investigation and cleanup came to a standstill over the last seven years. The Forest Service again chose to ignore the explicit recommendations of the Preliminary Assessment of the Mountain Fuel Mine that was completed in 2000. Following this assessment, no further investigation whatsoever occurred at the site. The Forest Service also failed during those seven years to enter into any agreement with Nu-West to conduct a Site Investigation, EE/CA or RI/FS. Again, this failure

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[78] USDA Forest Service, Phosphate Newsletter, November 27, 2007.
[79] USDA Forest Service. Memorandum to Regional Forester, Champ Mine, Transition from Removal to Remedial Process under CERCLA, February 21, 2007.
[80] Jack Troyer, Regional Forester, USDA Forest Service to Lisa Evans, Earthjustice, letter dated June 28, 2007, p. 2.

contradicts the Preliminary Assessment's explicit recommendation that further investigation be initiated. According to the Forest Service's own description:

> The dumps [at the Mountain Fuel Superfund Site] contain more than 13 million cubic yards of material. … Seasonal and regional groundwater found in some pits at the Mountain Fuel Mine have been found to have contaminant concentrations indicative of a hazardous substance release. In a Preliminary Assessment (PA) for the site, the contractor recommended additional characterization of the potential surface water contamination, as well as additional characterization of groundwater, soil and bioaccumulative effects from the Mountain Fuel Mine.[81]

According to the Forest Service, negotiations for an AOC for an EE/CA were initiated but never completed. In a puzzling statement, the Forest Service stated that in 2005, Nu-West offered to enter into an AOC to complete the EE/CA, but the Forest Service did not enter into any agreement.[82] Now the Forest Service plans to address the site under the CERCLA remedial program because "the Mountain Fuel Mine is large and complex; it may require pilot studies; and it is likely to require long term water treatment, monitoring and maintenance. All of these items are more appropriately managed within the CERCLA remedial process than in the CERCLA removal process."[83] In May 2007, the Forest Service sent Nu-West a proposed Administrative Settlement Agreement and Order on Consent for an RI/FS at the Mountain Fuel Mine Superfund Site.[84] It is not known when, or if, an agreement for an RI/FS will be reached.

Conclusion

The Forest Service's unfailingly dismal track record addressing CERCLA sites is overwhelming evidence that their promises of successful cleanup and remediation of the Superfund Site at Smoky Canyon Mine are baseless.

D. Laying the Groundwork for Failure

1. The Proposed Store and Release Cover Design For Panels F and G

As documented above, recent attempts to isolate selenium and other pollutants from the environment by implementing various new and untested reclamation designs have failed as have attempts to remedy those failures. Given this track record, the agencies should have approached the idea of the proposed "store and release" cover design for Panels F and G in a truly conservative way. Although the agencies allege that they were approaching the proposed

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[81] USDA Forest Service. Memorandum to Regional Forester, Mountain Fuel Mine, Transition from Removal to Remedial Process under CERCLA, February 21, 2007.

[82] Ibid.

[83] Ibid.

[84] Jack Troyer, Regional Forester, USDA Forest Service to Lisa Evans, Earthjustice, letter dated June 28, 2007, p. 2.

EXHIBIT D

Appendix 2A

CERCLA Investigations and Response for Smoky Canyon Mine and South Fork Sage Creek

SMOKY CANYON MINE
CERCLA INVESTIGATIONS AND RESPONSE

Smoky Canyon Mine
CERCLA Investigations and Response

Introduction

The goal of this appendix is to expand on the text in the EIS and demonstrate that with the regulatory status of the CERCLA action, and the actions taken by the agencies and implemented by Simplot, the segment of lower Sage Creek, currently exceeding the standard for selenium, would not be exacerbated by impacts from the proposed Panels F and G mine expansion. Response actions initiated in 2006, intended to curtail the release of selenium from the Pole Canyon portion of the site, are anticipated to substantially reduce the presence of contaminants prior to the predicted peak impacts from the proposed Panels F and G mine expansion.

Sage Creek currently has elevated selenium concentrations derived from the existing Smoky Canyon Mine. Sage Creek selenium concentration currently exceeds the chronic water quality standard for selenium in surface water, at least part of the year.

The agency Preferred Alternative for the mine expansion includes Alternative D; a cover system designed to reduce infiltration into the overburden thereby reducing the amount of water available to leach selenium and enter the ground water system. In addition, the cover system also increases the amount of time until which water quality impacts are expected to reach their peak concentrations.

Groundwater impact analyses conducted for the EIS indicate that the agency Preferred Alternative is expected to impact water quality at South Fork Sage Creek Spring, which flows into the main stem of lower Sage Creek in the southern part of Sage Valley. The peak selenium concentration at the spring resulting from the mitigated mine operations is predicted to be approximately 0.0025 mg/L, or about half the current selenium chronic water quality standard (0.005 mg/L). The peak concentration is predicted to occur about 120 years after the percolation from the overburden enters the groundwater. The model used to predict selenium concentrations downstream of South Fork Sage Creek in Sage Creek indicates the proposed mitigated mine operations would not exacerbate the current selenium concentration situation in lower Sage Creek. When the estimated effectiveness of the Pole Canyon ODA removal action is included in these calculations, the selenium concentration in lower Sage Creek is predicted to be below the selenium surface water standard.

Regulatory Status

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) was enacted by Congress in 1980 and substantially amended in 1986 in the Superfund Amendments and Reauthorization Act (SARA). The Act was enacted to respond to pollution and the threats posed to human heath and the environment resulting from the release, or imminent threat of a release, of Clean Water Act hazardous substances. CERCLA provides that the parties responsible for the pollution pay the costs to investigate and remediate contaminated sites, and it provides that an orderly investigation is conducted under the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). U.S. Department of Agriculture delegations to administer CERCLA were provided by the President in Executive Order 12580, in response to hazardous substance releases affecting National Forest System lands.

The Smoky Canyon Mine is located on National Forest System lands leased to Simplot by the Department of Interior to mine phosphate. The Forest Service completed a Site Investigation and determined that selenium and other hazardous substances are being released from the site into the environment. The Site Investigation found that rock mined as overburden provided the sources for releases. Most of these facilities were constructed prior to the discovery of selenium releases. Since discovery, mining companies and the regulatory oversight agencies have worked to understand release mechanisms and to develop best management practices to minimize releases.

In 2003, Simplot entered into an Administrative Order on Consent (AOC) to conduct a Site Investigation (SI) and Engineering Evaluation/Cost Analysis (EE/CA) with the U.S. Forest Service, the Idaho Department of Environmental Quality (IDEQ), and the U.S. Environmental Protection Agency (EPA). The AOC and it's accompanying Scope of Work (SOW), obligate Simplot to investigate the release or the threat of a release of hazardous substances, listed at 40 CFR 300, from their phosphate mining and milling operations at the Smoky Canyon Mine (Site). In the AOC, Simplot agreed to develop a range of response action alternatives in an EE/CA as remediation to the releases or threatened releases identified in the SI. The Forest Service as lead agency then selects alternatives for implementation based on implementability, feasibility, and cost.

The AOC divides the Site into two areas of study, Area A and Area B. Area A consists of Panels A, D, E, and Pole Canyon or the inactive portions of the mine located on National Forest system land under lease and special-use permit to Simplot. Area B is the tailings ponds area, which is located on Simplot-owned property east of the existing mine.

In accordance with the AOC, a Site Investigation (SI) conducted in 2003 and 2004, and finalized in a July 2005 report, demonstrates the release of Clean Water Act (CWA) hazardous substances from the Smoky Canyon Mine. The SI Report identifies existing environmental conditions that represent releases from the Site presenting unacceptable risks to ecological and human receptors. Data gathered during the investigations shows where and when exceedances of applicable environmental standards were measured at the Site. Alternatives to remedy conditions at the Site, presented as removal actions, were developed by Simplot in the EE/CA. The alternatives were then evaluated by the Forest Service for implementability, effectiveness, and cost.

On May 28, 2006 and again on June 8, 2006, the USFS published notices of availability for public comment on the Smoky Canyon Mine EE/CA.

As indicated in the EE/CA, a primary area of concern at the Site is the 26 million cubic yard Pole Canyon Overburden Disposal Area (ODA). The Forest Service preferred removal response action alternatives identified for the ODA include diversion of Pole Canyon Creek around the ODA, an infiltration gallery, and installation of run-on control ditches to manage water currently infiltrating through the ODA and discharging to surface and groundwater. The Forest Service accepted the Simplot EE/CA as a final EE/CA only for the purpose of evaluating and selecting non-time critical removal response actions related to the diversion of water from the Pole Canyon ODA (Forest Service response to public comments, October 2, 2006). Because the response actions selected by the Forest Service isolate waste rock stored in the ODA from Pole Canyon Creek, the load of selenium transported from the embankment into the creek, into the down gradient alluvial aquifer, and underlying Wells formation, is predicted to drop substantially. A reduction in the chemical load dissolved in water infiltrating to the Wells formation aquifer beneath the ODA is predicted to result from this set of actions.

Effective October 18, 2006, Simplot entered into a settlement agreement with the Forest Service, EPA, and IDEQ under which Simplot is obligated to implement the removal response actions selected by the Forest Service. Those actions serve to remediate the transportation of selenium from the Pole Canyon ODA via Pole Canyon Creek and runoff from the surrounding landscape, as described in the Action Memorandum. Simplot has posted a $2.9 million bond to guarantee their performance of the work according to approved plans.

Hydrogeological Conceptual Model for Pole Canyon ODA

The SI found that the Pole Canyon ODA contributes a substantial selenium load to Sage Creek. A portion of the load can be seasonally contributed through surface water and a larger portion is contributed through the groundwater to Hoopes Spring, which discharges into Sage Creek. The SI data found Sage Creek water to exceed the State and CWA standard of 0.005 mg/L much of the year.

The Pole Canyon ODA is distinct from other Smoky Canyon Mine overburden fills because of its canyon backfill setting and the presence of an underlying shallow alluvial groundwater system associated with Pole Canyon Creek and extending into Sage Valley. The creek enters the west end of the ODA, flows east through the base of the overburden along the original creek channel through waste rock, and discharges from the east end, or downstream toe of the ODA. Pole Canyon Creek leaves the toe of the ODA channel, and from there it flows downstream into Sage Valley. Water discharging from the downstream end of the channel has concentrations of selenium up to 1.5 mg/L.

Along the flow path from the ODA into Sage Valley, Pole Canyon Creek loses flow as it infiltrates to both the underlying alluvial groundwater flow system and the underlying bedrock. Surface water monitoring during the SI period indicates that Pole Canyon Creek loses all flow a short distance downstream from the ODA during low flow seasons (summer, fall, winter). During spring high flows, this same monitoring indicated that, with the exception of spring 2006, all flow in Pole Canyon Creek is lost to its channel or from irrigation diversions before its confluence with Sage Creek.

Pole Canyon Creek water percolating into the Wells formation migrates vertically downward through approximately 200 feet of unsaturated bedrock. Wells formation groundwater below Pole Canyon flows a short distance east from the ODA to the West Sage Valley Branch Fault, which acts as a boundary preventing further eastward flow. Upon reaching the fault, the SI report states that groundwater flows south along the fractured fault zone to eventually discharge approximately two miles south at Hoopes Spring. Selenium discharged with groundwater at Hoopes Spring flows to lower Sage Creek via surface water flow. Selenium concentrations at Hoopes Spring have been steadily increased since about 1989 and now range up to 0.019 mg/L, several times the standard of 0.005 mg/L.

Selenium concentrations in lower Sage Creek vary seasonally. Base flow in lower Sage Creek is mostly supported by flow from Hoopes Spring and South Fork Sage Creek Spring, which both enter Sage Creek in the southern part of Sage Valley. Given the relatively uniform flow and elevated selenium concentrations in Hoopes Spring, even with the dilution provided by clean flow from South Fork Sage Creek, exceedances of the CWA selenium standard persist downstream of Hoopes Spring during low flow periods. During spring runoff, additional clean runoff water moving through the Sage Creek and South Fork Sage Creek drainages produces the highest amounts of dilution for the Hoopes Spring water and typically the lowest seasonal selenium concentrations, typically in compliance with the water quality standard. Where past

monitoring indicates selenium concentrations complied with CWA standards in Lower Sage Creek during high flows, in 2006 selenium concentrations over the CWA standards persisted downstream into Crow Creek during peak runoff flow. This was due to surface water flow from Pole Canyon Creek contributing selenium load directly to lower Sage Creek. This had not occurred in the previous 10 years of sampling.

According to the SI Report approximately half of the selenium load leaving the Pole Canyon ODA reports to the underlying Wells formation annually (approximately 300 lbs. per year). The estimated selenium mass balance was developed with two years of data from SI monitoring well GW-16, where relatively consistent water levels and selenium concentrations are measured in the Wells formation immediately downstream of the Pole Canyon ODA and down-gradient discharges were measured from Hoopes Spring

Forest Service Preferred Alternative Smoky Canyon EE/CA

Section 5.2.2.3 of the Smoky Canyon Mine EE/CA summarizes Alternative 3 for the Pole Canyon ODA, the Forest Service preferred alternative. Under this alternative, Pole Canyon Creek flow into the ODA would be eliminated or significantly reduced by diverting creek flow around the ODA and by infiltrating flow into the Wells formation upstream of the ODA. Approved plans indicate the diversion pipe would divert the flow of Pole Canyon Creek far enough upstream of the ODA to allow gravity flow over the ODA. Overflow from the diversion during runoff and storm events would flow downstream and into a settling and infiltration basin excavated upstream of the ODA. Water captured in the basin would infiltrate into the Wells formation unimpacted by mining activities. As percolation carries infiltrating water deeper into the Wells formation the EE/CA predicts it would pass through bedrock under the ODA without contacting overburden materials. Surface water run-on controls included with the set of alternatives diverts snowmelt and stormwater away from the ODA in a series of ditches in an effort to isolate this component of flow. Plans approved for implementation provide that the infiltration basin and diversion would be managed to provide unimpacted water to support downstream beneficial water uses in Sage Valley and further downstream.

The agencies have identified as a priority the need for response actions to reduce selenium transport from the Pole Canyon ODA to Sage Valley and to Hoopes Spring. Selenium concentrations down gradient of the Pole Canyon ODA are above applicable standards. Hoopes Spring, the headwaters of a fish-bearing stream, exceeds the chronic cold water biota standard for selenium as documented increases are approaching the acute criteria.

The EE/CA proposed several alternative packages to control selenium releases from the Pole Canyon ODA. The primary environmental issues to be addressed are the leaching of selenium from the flow of Pole Canyon Creek through the ODA and the infiltration of water through the ODA from direct precipitation and run-on.

1. **No Action:** No action would be taken.

2. **Treatment:** Pole Canyon Creek would continue to flow through the ODA. The surface of the ODA would be treated with iron, chert, and topsoil. Ditches would be constructed to prevent run-on from adjacent hillsides. Detention pond (DP-14) would be covered with chert. Water flowing through the ODA would be treated through the addition of organics and iron either at the inflow or the outflow. Post action monitoring would be performed.

3. **Diversion:** Pole Canyon Creek would be diverted around the Pole Canyon ODA. The surface of the ODA would be amended with organic material. Ditches would be constructed to prevent run-on water from adjacent hillsides. Detention pond (DP-14) would be removed along with approximately 30 cubic yards of sediment. Post action monitoring would be performed.

4. **Cap:** Pole Canyon Creek would be diverted around the Pole Canyon ODA. A low-permeability geo-synthetic liner would be placed over the ODA and covered with topsoil. Ditches would be constructed to prevent run-on from adjacent hillsides. Detention pond (DP-14) would be removed along with approximately 30 cubic yards of sediment. Post action monitoring would be performed.

The Action Memorandum, finalized October 2, 2006, approves the following selected actions to reduce selenium release from Pole Canyon ODA. Pole Canyon Creek flow into the ODA would be eliminated or significantly reduced by diverting creek flow around the ODA and by infiltrating flow into the Wells formation upstream of the ODA. The diversion line would be a buried pipeline diverting the flow of Pole Canyon Creek far enough upstream of the ODA to allow it to gravity flow over the ODA. A settling basin would be installed upstream of the infiltration gallery to remove sediment from the stream flow prior to entry into gallery and to prevent development of a sediment seal in the infiltration basin. The infiltration basin would be located immediately upgradient of the ODA to allow clean creek surface flow to infiltrate into the Wells formation and pass under the ODA without contacting overburden materials. Surface water run-on controls would also be included with this alternative. The infiltration basin and diversion would be managed to provide unimpacted water to support downstream beneficial water uses in Sage Valley and further downstream.

Consistent with the Action Memorandum and Administrative Settlement Agreement on Consent, construction of the Pole Canyon Creek diversion began in October 2006.

In review of the EE/CA alternatives developed by Simplot for the removal action, the Forest Service determined that a permanent solution for the remediation of the Smoky Canyon site other than the Pole Canyon ODA was not presented in adequate detail to support a long-term solution. Subsequently, the Forest Service plans to evaluate the data presented in the SI and EE/CA under remedial response process described in the NCP. Negotiations with Simplot to convert from the removal action process to the remedial process are planned for the winter of 2006-2007.

Prediction of Water Quality Improvements at Hoopes Spring in Response to the Pole Canyon Creek Diversion

Modeled estimates provided in the EE/CA state that the diversion of Pole Canyon Creek coupled with infiltration upstream of the ODA would isolate 93 percent of the water currently entering the overburden (**Figure 1**). Run on controls are estimated to eliminate an additional five percent of infiltration through the surface.

Some uncertainty remains with regard to the relative contribution of the different sources of water inflows to the ODA. Somewhat more uncertainty exists regarding the relationship of these inflows to selenium release (i.e., selenium loading) from the overburden. However, the existing surface water and groundwater concentration and flow data provide a basis for developing conservative assumptions regarding loading contribution for the above-described pathways.

A review of these data indicates that the current creek flow through the overburden is responsible for the discharge of the largest selenium load from the Pole Canyon ODA. **Figure 2** contrasts seasonal changes in selenium concentrations, along with flow and water levels in the creek upstream and downstream of the ODA (UP, LP) and connected alluvial system (GW-15), and the underlying Wells formation (GW-16). These data indicate that, as the creek inflows increase, the selenium concentration and load in the creek and alluvial groundwater downstream of the ODA increases correspondingly. As the creek inflow diminishes, the selenium concentrations and load in the creek at the toe of the ODA also diminish. This pattern is consistent with Pole Canyon Creek inflow being the primary selenium transport pathway. Seasonal loading calculations for these pathways during the SI period are shown in **Figure 3**. Although the loading is not directly proportional to inflow (e.g. Pole Canyon Creek is estimated to be 93 percent of the water entering the overburden) the seasonal pattern of loading indicates that the creek inflow provides the majority of transport and release to the environment in the spring of the year. This is consistent with observations at non-cross valley fill overburden disposal areas, where the selenium loading potential is much lower.

Given the data presented in the SI report, it was calculated that the planned Removal Action would eliminate up to 98 percent of the water flowing through the overburden (93 percent = Pole Canyon Creek, 5 percent = run-on) and would provide a 75 percent reduction in selenium mass transport.

Calculations using 75 percent reduction in load from Pole Canyon as the single source of selenium discharged from Hoopes Spring results in lowered discharge concentrations from the current measured range to less than 0.005 mg/L, once selenium currently in the flow path is discharged or diluted. A significant decrease in the Hoopes Spring selenium would correspond to a reduction in the Sage Creek selenium concentration downstream of Hoopes Spring. Typically, lower Sage Creek is just over the selenium water quality standard for part of the year. A decrease in selenium concentration at Hoopes spring is estimated to cause Sage Creek to be below the standard on a year-round basis.

As documented in the spring of 2006, above normal winter snow pack can cause Pole Canyon Creek to flow to Sage Creek increasing the selenium concentration and load carried downstream in Sage Creek. Because of the approved diversion around the ODA, water discharging from the diverted Pole Canyon Creek would no longer have a selenium load. Assuming the diversion effectively isolates Pole Canyon Creek from contact with mine overburden, future connections directly to Sage Creek would no longer add a selenium load. Residual seepage from the Pole Canyon ODA may still occur during the peak snowmelt conditions in the spring, however, when mixed with the clean flow of Pole Canyon Creek, dilution would reduce water concentrations.

Time to Achieve Water Quality Improvements at Hoopes Spring

The diversion of Pole Canyon Creek and reduction of run-on water are expected to have a relatively immediate positive effect on the groundwater directly beneath the ODA. An estimation of the time it will take to see measurable effects at Hoopes Spring is more difficult.

Analytical models, developed for the SI, based on gradient, hydraulic conductivity, and porosity of the Wells formation calculate groundwater travel time from the Pole Canyon Creek area to Hoopes Spring. However, the most reliable prediction for improvements to be observed at Hoopes Spring is the time it took selenium to appear once construction of the ODA began. **Figure 4** shows the change in selenium concentration in Hoopes Spring with time relative to the

period of overburden backfilling at Pole Canyon. The Pole Canyon ODA construction began in 1985 and continued to the early 1990s. Using roughly the midpoint of the backfilling (1988) and the obvious initial point of concentration increase in Hoopes Spring (1998) indicates that it took approximately 10 years for measurable selenium to appear. This period is consistent with the calculated transport velocity of slightly less than 3 feet per day.

In consideration of the above, it is anticipated that the effectiveness of the Pole Canyon ODA removal actions at Hoopes Spring could be witnessed in roughly 10 years. However, it is important to note that confirmation of the expected effectiveness may occur sooner. The strategic location of monitoring wells GW-15 and GW-16 allow for real time monitoring of residual selenium concentrations and loading potential for the alluvial and Wells formation groundwater pathways, after completion of the Removal Action. A reduction in selenium loading should be first observed at GW-15. Slightly more time may be required to observe a water quality change in the Wells formation at the deeper GW-16, given the thickness of the overlying unsaturated zone. Still, within a few years post construction, the effectiveness of the Pole Canyon actions should be evident at GW-16. Collection of these post action effectiveness monitoring data will allow for more accurate predictions of the magnitude and timing for selenium concentration reductions at Hoopes Spring.

The diversion of Pole Canyon Creek around the ODA is expected to reduce the selenium load in surface water flow Pole Canyon Creek down stream of the ODA to near background levels. Results are expected to be nearly immediate upon full implementation of the diversion.

Schedule for the Pole Canyon Removal Action

An Action Memorandum approving implementation of a Removal Response Action at the Pole Canyon ODA at the Smoky Canyon Mine was signed October 2, 2006. An Administrative Settlement Agreement and Order on Consent was entered into by J.R. Simplot Co., the Forest Service, IDEQ, U.S. EPA, and the Department of Justice, effective on October 18, 2006. A Statement of Work (SOW) required to complete the diversion of Pole Canyon Creek around the ODA was attached.

On October 6, 2006, the Forest Service authorized Simplot to begin tree removal and grading for the pipeline trench, which Simplot initiated the following week. Simplot purchased and received the necessary pipeline material, and construction of the diversion will continue into the remainder of 2006 as long as weather and site conditions allow, final work is planned for completion of the project during the summer of 2007.

Future Remedial Actions

The removal response actions currently underway at the Smoky Canyon Mine are the first of what are expected to be several CERCLA response actions at the site. Pole Canyon represents only a small portion of this large site. The Forest Service expects to convert the removal action SI and EE/CA to a more comprehensive remedial action. The Remedial Investigation would build upon the existing data to develop alternatives in a Feasibility study to provide a long-term solution to this complex site. The Forest Service and support agencies expect that the anticipated remedial action combined with the currently approved actions will result in a comprehensive cleanup effort. Capping to reduce or prevent infiltration, soil and waste amendments, revegetation, and water treatment are all envisioned as additional potential responses. Current actions taking place at the Pole Canyon ODA are likely only a component of the final remedial action.

Simplot has begun conducting greenhouse studies to analyze the effects of mixing biosolids with overburden materials on the surface of the ODA intended to reduce infiltration into the ODA and produce a reduction in bioaccumulation by reclamation plantings.

Simplot Proposed Interim Water Management Options

Simplot currently developed a plan with the Petersen Ranch downgradient of the site in Sage Valley to improve the efficiency of Petersen's current flood irrigation system in Sage Valley. Historically, the Petersen family has irrigated the middle and lower portions of Sage Valley by diverting water from Sage Creek and Hoopes Spring through a series of unlined ditches. Water diverted from these ditches is used to flood irrigate pasture used to raise livestock. Petersen diverts stream water from Pole Creek, Sage Creek, and Hoopes Spring pursuant to existing water rights. Planned modifications are consistent with the points of diversion and places of use described under these existing water rights, and focus on improved efficiency of delivery and application of diverted flows.

Within the limits of Petersen's existing water rights, the goals of the planned improvements are to optimize the use and efficiency of the Hoopes Spring irrigation water and to eventually improve the efficiency of the Sage Creek diversion and application system. In combination, these improvements aim to reduce the volume of water diverted from Sage Creek. Implementation of the sprinkler design is predicted to irrigate more pasture while using less water than is currently diverted from Sage Creek. If the project works as anticipated, more water would be left in Sage Creek to dilute selenium concentrations downstream of Hoopes Spring, resulting in reductions of selenium concentrations in lower Sage Creek.

Current Irrigation Practices and Planned Improvements

The Peterson Ranch has the following water rights for irrigation of Sage Valley:

Sage Creek:	15.78 cfs
Hoopes Spring:	2.54 cfs

Flow from these streams is currently diverted, part of the year, to a series of unlined ditches. Using branch ditches and earthen dams, the water is further distributed for flood irrigation. The existing flood irrigation systems are inefficient because unlined earthen ditches leak and result in an uneven distribution pattern.

Simplot owns the parcel of land containing the headwaters of Hoopes Spring. Improvement design plans for the Hoopes Spring irrigation system include the collection of the 2.54 cfs diverted from Hoopes Spring, a pumping basin, and a distribution pipe feeding multiple irrigation spray/sprinkler guns. System designers expect their system will provide a more effective and efficient means of transporting and applying irrigation water to the place of use currently irrigated. Agreements with Mr. Peterson will be in place before putting the sprinkler system in operation.

A second phase of improvements focuses on the system used to deliver irrigation water from upper Sage Creek to the middle Sage Valley. Currently, Petersen can divert up to 15.78 cfs from Sage Creek for irrigation. Water diverted into these ditches is then conveyed to the north and to the south, to the extent gravity allows. A series of canvas check dams and smaller lateral ditches convey water to various parcels for flood irrigation. Diversions placed by Petersen divert most of the flow in upper Sage Creek during the summer months leaving a

reduced base flow in the native channel between the diversion and the confluence with Hoopes Spring.

Both the main irrigation ditches and smaller lateral ditches are subject to substantial water loss through infiltration with little sub-irrigation benefit. The planned replacement of the ditch with a pipe delivery system is expected to improve efficiency by more than 50 percent. As a result, the place of use will be irrigated with less water diverted from Sage Creek. The improved efficiency should result in a substantial increase in summer base flows for lower Sage Creek, below irrigation diversions. Increased summer base flows would result in increased dilution of selenium starting at the confluence with Hoopes Spring flow. Implementation of the project to conserve water in lower Sage Creek would be contingent on agreements with the Peterson Ranch and the State of Idaho to allow the surplus water to remain in Sage Creek.

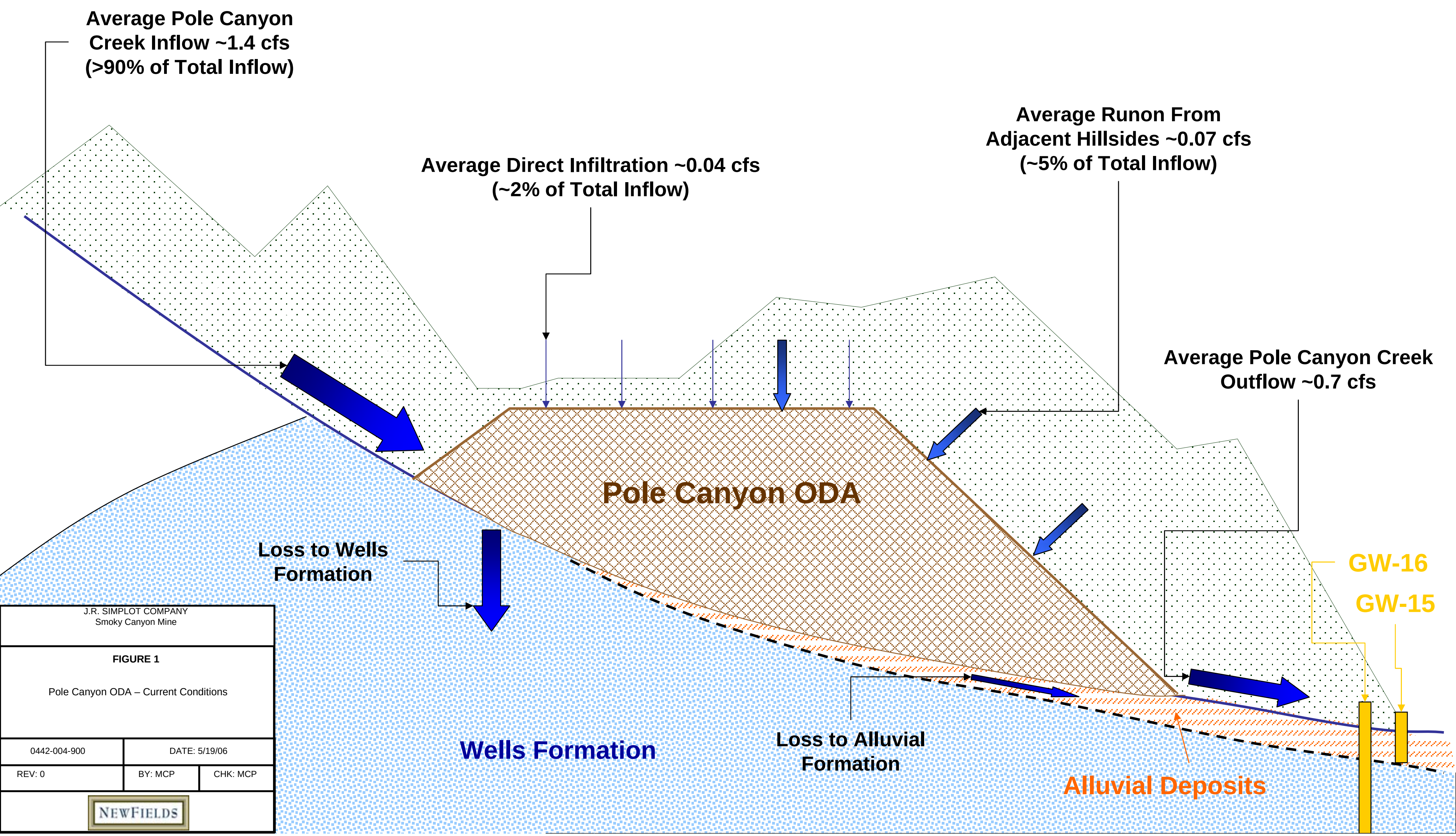
Selenium concentrations in vegetation in areas receiving Hoopes Spring irrigation water could increase slightly. However, Simplot does not expect that concentrations will increase substantially. Based on available information for Pole Canyon Creek irrigated areas, Simplot and IDEQ believe selenium concentrations in vegetation should remain well below the 5.0 mg/Kg selenium dry weight concentration in vegetation identified in IDEQ's "*Area Wide Risk Management Plan"* as a level of concern for livestock and grazing wildlife. Vegetation samples collected before, during and after irrigation would be analyzed according to the monitoring procedures, described in the *Smoky Canyon Mine Site Investigation Sampling and Analysis Plan*, to assure that the improvements in irrigation efficiency do not result in the bioaccumulation of selenium concentrations that would present an unacceptable risk to foraging animals.

Simplot believes that the improved irrigation efficiency and low selenium concentrations of the Hoopes Spring water relative to cattle ingestion and temporary ponding of water do not pose an exposure concern, although the system can be adjusted as necessary to minimize pollution potential.

In addition to the vegetation monitoring specific to the areas of application of Hoopes Spring water, surface water monitoring, as required to measure the effectiveness of remediation at the mine, would be continued in lower Sage Valley. Monitoring would evaluate the changes in water quality, selenium concentrations in vegetation, and pasture utilization. Lower Sage Creek would continue to be monitored monthly for selenium concentrations above and below the confluence with Hoopes Spring.

After monitoring the effectiveness of the irrigation improvements described above, Simplot, together with the Petersens, may consider additional water management options on adjacent private lands. Such options may include further irrigation system improvements to further improve the efficiency of the water diverted from Sage Creek. For example, an exchange between Hoopes Spring and Sage Creek to increase the amount of Hoopes Spring water used for irrigation may have a net effect to further reduce selenium concentrations within Hoopes Spring and further reduce selenium concentrations in lower Sage Creek. Simplot proposes to implement water management actions in the interim application until removal response actions implemented at Pole Canyon ODA demonstrate reductions in selenium concentrations in Hoopes Spring. Any such future surface water management options would be developed and pursued under the existing or future CERCLA agreements.

POLE CANYON ODA – CURRENT CONDITIONS



J.R. SIMPLOT COMPANY Smoky Canyon Mine	
FIGURE 1 Pole Canyon ODA – Current Conditions	
0442-004-900	DATE: 5/19/06
REV: 0	BY: MCP CHK: MCP
NEWFIELDS	

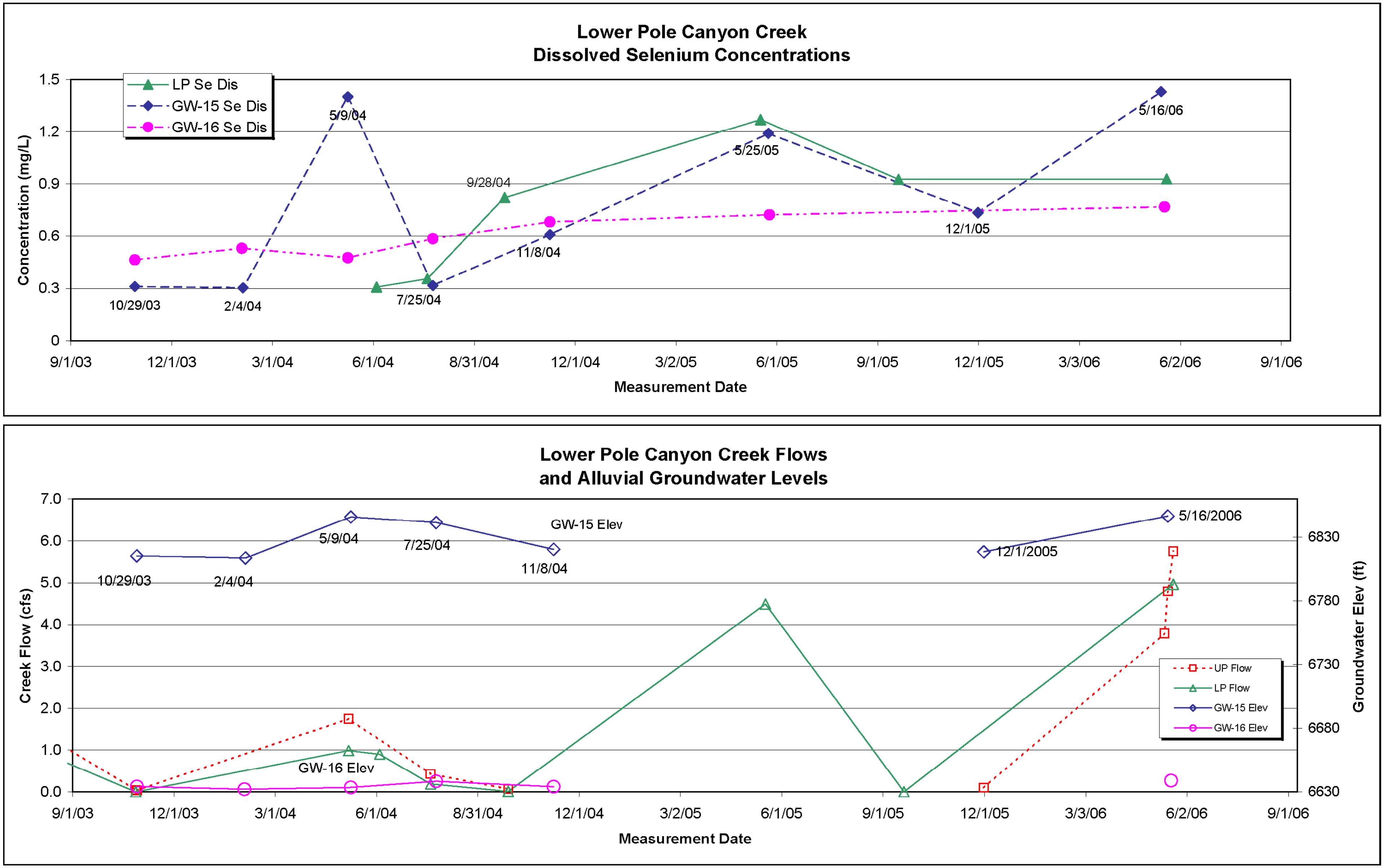


Figure 2. Flow, concentration and water levels in Lower Pole Canyon.

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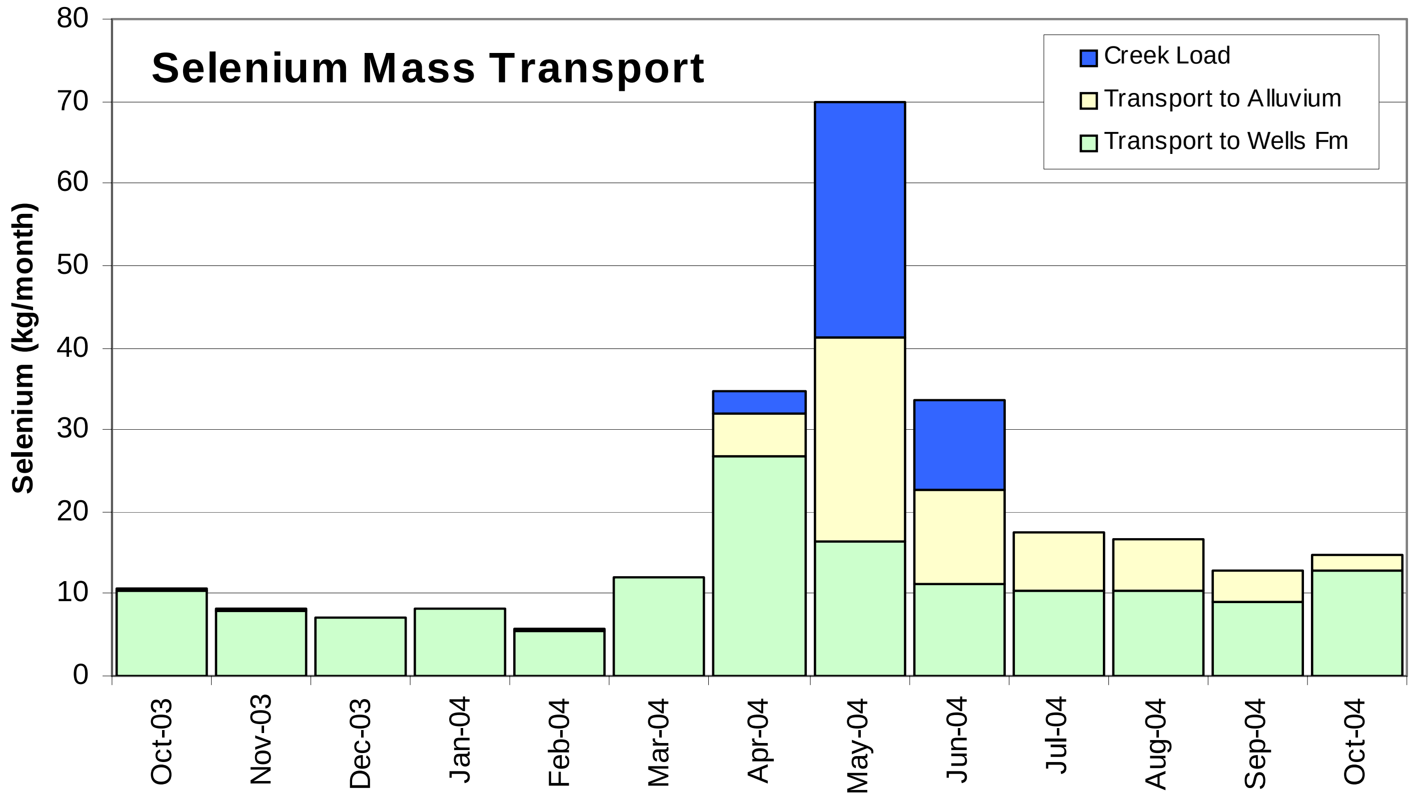

J.R. SIMPLOT COMPANY Smoky Canyon Mine	
FIGURE 3 Selenium Mass Transport from Pole Canyon Overburden Disposal Area	
PROJ: 01-0109-1	DATE: March 5, 2005
REV: 0	BY: KJT CHK:
NEWFIELDS	

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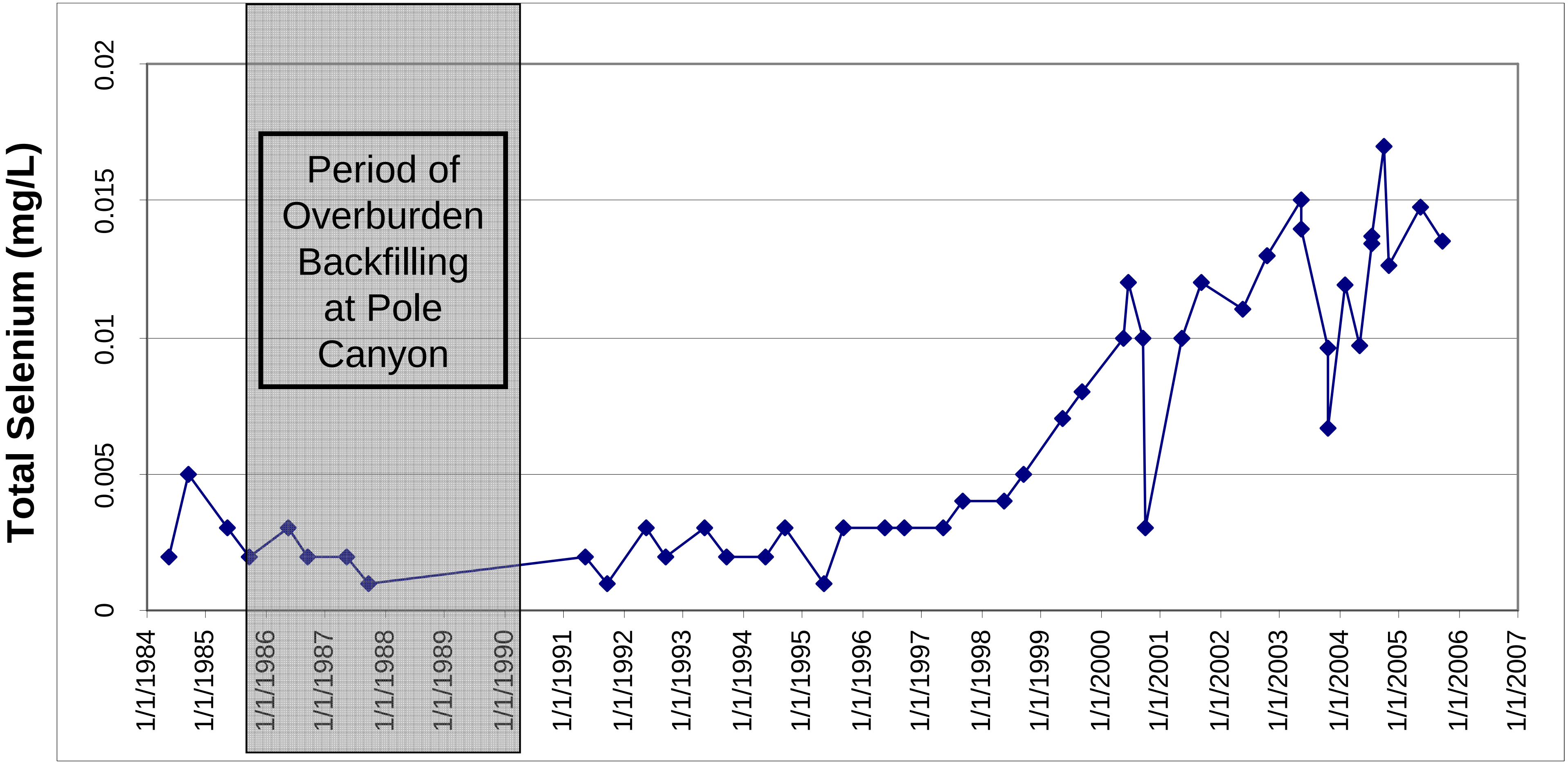
Selenium in Hoopes Spring Water



J.R. SIMPLOT COMPANY Smoky Canyon Mine		
FIGURE 4 Selenium in Hoopes Spring Water		
0442-004-900	DATE: 5/19/06	
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NEWFIELDS		

EXHIBIT E

1.0 INTRODUCTION

The J.R. Simplot Company (Simplot) owns and operates the Smoky Canyon phosphate mine in southeastern Idaho (Figure 1-1). The Smoky Canyon mine is the subject of an Administrative Order on Consent (AOC) entered into by the State of Idaho Department of Environmental Quality (IDEQ), the U.S. Forest Service (USFS), the U.S. Environmental Protection Agency (EPA), and Simplot (IDEQ, USFS and EPA, 2003). The AOC, and its accompanying Scope of Work (SOW), provide a mechanism to investigate the potential environmental effects of phosphate mining and milling operations at the Smoky Canyon mine and develop remedies to address any environmental conditions that represent a risk to human health or the environment.

The AOC divides the Smoky Canyon Mine into two areas of study, Area A and Area B. Area A (referenced as “the Site” in this report) consists of the extent of the mine at the time the AOC was signed (mine panels A, D and E) and related facilities located on National Forest system land (Figure 1-2). Area B is the Smoky Canyon mine tailings ponds area, which is located on Simplot-owned property (Figure 1-2).

In accordance with the AOC, a Site Investigation (SI) and Engineering Evaluation/Cost Analysis (EECA) are being conducted to evaluate and address environmental conditions within Area A. The purpose of the Area A SI is to identify existing conditions that either represent unacceptable risks to ecological and human receptors or do not meet applicable standards for environmental quality. Such conditions are to be addressed through removal actions[1] developed and evaluated is this EECA. Specifically, Simplot is to conduct an EECA to develop and evaluate removal action alternatives to address any unacceptable environmental conditions for the historical (inactive) portions of the Site. The Site conditions evaluated through the SI and EECA are those that exist as a result of the past mining activities performed under the original Bureau of Land Management (BLM) and USFS-approved mine plan.

The USFS is the lead agency for Area A studies with IDEQ, the BLM, U.S. Fish and Wildlife Service (USFWS), EPA, the Bureau of Indian Affairs (BIA) and Shoshone-Bannock Tribes designated as support agencies.

The SI was performed during 2003 and 2004 in accordance with the scope of work presented in the Area A Site Investigation Work Plan (MFG, 2003a) and procedures described by the Field Sampling Plan (FSP) for the SI (MFG, 2003b). The findings of the investigation, including the nature and extent of contamination, the fate and transport of constituents of potential concern

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[1] “Removal Actions” is the regulatory label given to remedial actions identified through the EECA process. Removal actions include the full range of source control, treatment, and institutional controls.

(COPCs) and resultant risks to human and ecological receptors, were detailed in the SI Report (NewFields, 2005).

The findings presented in the SI report serve as the basis for identifying the removal action goals (RAGs) and support the evaluation of removal actions designed to achieve the objectives and goals presented in this EECA.

1.1 Background Information

Beginning in 1996, isolated livestock deaths associated with excessive selenium intake in the vicinity of historic phosphate mines in southeast Idaho (i.e., South Maybe Canyon, Wooley Valley and Conda mines) prompted concerns within various state and federal agencies regarding potential human health and ecological effects from the past mining operations. In response to these concerns, the primary mine operators in the region formed the Idaho Mining Association (IMA) Selenium Committee to jointly and voluntarily investigate and address any mining-related environmental and public health issues associated with the past operations. Similarly, an interagency and industry group, the Selenium Working Group, was formed to facilitate voluntary collaboration among the participating federal, state and tribal agencies as well as other stakeholder groups, including the phosphate mine operators. In 2000, many of these same parties entered into an AOC, known as the Area-Wide AOC, to formalize their agreement to evaluate and address both area-wide and site-specific human health and ecological risks related to past phosphate mining practices in southeastern Idaho. Parties to the Area-Wide AOC include IDEQ, USFS, BLM, EPA, USFWS and five mining companies, including the J.R. Simplot Company. The Area-Wide AOC establishes the process used to conduct investigations and characterize risks associated with historic and active mining at an "Area-Wide" scale. The Area-Wide AOC required Simplot to enter into the previously described AOC to conduct a SI/EECA specifically for Area A of the Smoky Canyon Mine.

Area A consists of the mine and related facilities located on National Forest system land under lease and special-use permit to Simplot (Figure 1-2), and it also includes the areal extent of contamination beyond those leases and the special-use permit area, as identified through the SI. As such, Area A comprises all areas of the Site developed to date, except for the tailings impoundments (Area B), ongoing mining at the E Panel, and recently permitted activities specifically associated with the Panels B and C 2002 Mine Plan, including backfilling of the A Panel pit with B & C Panel overburden (BLM and USFS, 2002).

1.2 Historical and Current Mining Activities and Relationship to the EECA

Mining at E Panel and the newly opened Panels B and C is occurring under the current Mine Plan (BLM and USFS, 2002), which includes requirements for reclamation of mining features once activities are complete. Reclamation procedures and operations have been modified since

the beginning of mining in 1983 (BLM and USFS, 1981), and in particular, since the potential for selenium releases to the environment and associated risks were more recently identified. Reclamation has included simple contouring and seeding for the first panels mined through the current best management practices (BMPs). Recent and current closure and reclamation practices have been designed to be effective for addressing COPC releases at the Site. Current BMPs include management of mine materials to leave backfilled pits and external overburden disposal areas (ODAs) with a layer of chert over the seleniferous overburden prior to top-soiling and seeding the surface. Covering will isolate the seleniferous overburden from surface weathering, erosion and offsite transport in runoff. The soil cover will retain moisture and support vegetation which will reduce net infiltration. The underlying chert layer will minimize root penetration into the selenium overburden and prevent bioaccumulation of selenium by the reseeded grasses and herbaceous plants.

Actions considered under the EECA relate to features remaining from past mining activities. For features where reclamation activities required by the mine plan are ongoing, the EECA assesses the expected final condition of those areas as the starting point for evaluation of removal action alternatives. The final removal action selected will need to complement the ongoing reclamation activities and leave the Site in a condition that meets removal action objectives (RAOs) over the long term.

The Smoky Canyon Mine currently consists of mine panels A, B, C, D and E, which include open pits, backfilled pits and external ODAs (see Figure 1-3). The following provides a basic description of the operational status of the mine panels and identifies the specific mine features that are addressed in the EECA.

- **A Panel.** The A Panel was mined from 1984 through 1995. A portion of the pit was backfilled during mining and reclaimed with areas of topsoil and vegetation. This area and the remaining open portion of the pit are currently being backfilled with overburden from Panels B and C and reclaimed. The surface of the backfilled pit will be reclaimed in accordance with the 2002 Mine Plan (BLM and USFS, 2002) and is not addressed in the EECA.

- **A Panel External ODA.** Overburden was placed in the external ODA in 1984 and 1985. Some topsoiling and seeding reclamation activities were performed through 1989. The area is evaluated in the EECA.

- **Pole Canyon ODA.** Overburden from mining at A Panel was placed externally, in the eastern portion of Pole Canyon, from 1985 through 1990. The east side was sloped and seeded in 1992 through 1995. Overburden from mining at D Panel was placed on the west side in 1997 and subsequently reclaimed. The area is evaluated in the EECA.

- **D Panel Pit and External ODA.** The D panel was mined from 1992 through 1997. The pit was concurrently backfilled and overburden was also placed in an external ODA in 1993 and 1994. The pit and external ODA have been reclaimed using soil (northern area) or chert and soil (southern area) as cover. The northern area of the backfilled pit and the external ODA are evaluated in the EECA.

- **E Panel Pit and External Overburden Area.** Mining of the E Panel began in 1998. The panel has been mined and backfilled with the exception of E-0 pit, which continues to be mined. Simplot plans to ultimately backfill the E-0 pit with overburden from future mining at the proposed F and G panels to the south. Material was placed in an external ODA from 1998 to 2000. The external ODA has recently been backfilled and reclaimed, consistent with the current BMPs. The E Panel external ODA has a chert cap covered with topsoil and vegetation. The external ODA is evaluated in the EECA.

- **Panels B and C.** Mining is actively occuring in Panels B and C. As described above, some overburden is currently being placed to fill portions of A Panel. The areas disturbed by mining at B and C Panels are not included in Area A, as defined by the AOC, and therefore were not included in the SI investigations. These areas and the future Panels B and C backfilled pits will be reclaimed per the requirements of the 2002 Mine Plan (BLM, USFS, 2002) and are not addressed in the EECA.

1.3 EECA Approach

The EECA presents and evaluates a range of removal action alternatives to address unacceptable environmental conditions identified through the SI. The information is presented by source area and also considered on a Site-wide basis. Consistent with the AOC and the SI Work Plan (MFG, 2003a), principal components of this EECA are:

- Finalization of the RAOs to define the objectives of cleanup actions (preliminary RAOs were identified in Section 11.2.2 of the SI Report);

- Identification of an appropriate range of removal action alternatives;

- Detailed analysis of removal action alternatives against the CERCLA criteria of effectiveness, implementability and cost by source area;

- Comparative analysis of alternatives to evaluate the relative performance of each alternative in relation to each of the CERCLA criteria;

- Identification of the alternative(s) that has the highest relative performance and that is recommended for selection.

This approach is consistent with EPA EECA Guidance (EPA, 1993).

1.4 Report Organization

This report presents the findings of the EECA and is organized as follows:

- Section 2 reviews the screening criteria and applicable or relevant and appropriate requirements (ARARs) identified during the SI and provides goals and objectives for the removal action.

- Section 3 provides a summary of the findings of the SI, with particular focus on the areas and environmental issues that need to be addressed in the EECA.

- Section 4 describes technical information from testing at the Site, at other phosphate mines in the region, and at other sites within the United States that supports identification and development of an appropriate range of removal action alternatives.

- Section 5 identifies the removal action alternatives evaluated in the EECA and includes a discussion of options that were screened out from consideration.

- Section 6 describes the detailed analysis of the removal action alternatives against the EECA criteria of effectiveness, implementability and cost.

- Section 7 describes the comparative analysis, where the alternatives are compared and contrasted to identify the advantages and disadvantages of each alternative relative to one another and any key tradeoffs that would affect the remedy selection.

- Section 8 identifies a preferred group of removal actions that are recommended for comprehensive application at the Site.